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*THE GROUP-VELOCITY AND THE WAVE-VELOCITY OF LIGHT.**

ALTHOUGH the determination of the important constant of nature—the velocity of light—has occupied the attention of scientists from the time of Galileo, and while astronomical and terrestrial methods have been so carefully refined that individual observers have obtained values differing by less than one part in 3,000, it is a significant fact that no terrestrial method thus far used gives the absolute velocity of light under all conditions. If a group of periodic disturbances are radiated out into any medium the velocity of the individual elements will in general be different from that of the mean of the group. Only in the one instance, the propagation in vacuo, is it likely that these two velocities are the same; and here physical methods, thus far, have not put the question to a test. In the case of ponderable media important data are to be expected. The astronomical method used by Römer in 1675 and founded on the observation of the eclipse of Jupiter's satellites gives the so-called group-velocity of light in vacuo. The observation of the fixed stars discovered by Bradley in 1727 gives the wave-

* Address of the retiring President and Chairman of Section B—Physics—of the American Association for the Advancement of Science, Pittsburgh meeting, June 28 to July 3, 1902.

velocity in the medium within the observing telescope. This is the only method thus far used which gives the absolute velocity of light.

The uncertainty in the constant of aberration and the errors in the observations of Jupiter's satellites render these methods unsuited for the comparison of the two velocities. We owe perhaps to Arago more than any other person a solution of this problem of the velocity of light. In 1838 he submitted to the French Academy the plan of an experiment for solving directly and definitely the question—which was being much debated—whether light was a corpuscular emission from radiant bodies or simply the result of the vibrations of a very rare medium. The method was simply an adaptation of the rotating mirror ingeniously devised by Wheatstone for determining the velocity of propagation of electricity in a wire. It was not till 1850, however, that this method, in the hands of Foucault, was actually put to the test of determining this constant. In the preceding year, however, Fizeau had published the results of his experiments by means of a toothed wheel. These were the first observations made on the velocity of light at the earth's surface. The first idea of this method seems to have originated with the Abbé Laborde, who communicated it to Arago some years before. Upon these two principles is based our entire knowledge by terrestrial methods of this constant. On the one side we have the refinement and modifications of the toothed wheel as used by Cornu in France and Young and Forbes in England and on the other the very accurate results of Michelson in his classic experiments and those of Newcomb with his highly refined phototachometer in this country. It may well be questioned whether much greater certainty in data is attainable than those which the late lamented French savant and illustrious physicist Cornu has left as one of his most brilliant legacies to science. Nor can we hope for any considerable refinement in the determinations by the other method as used in this country, and which have already given the most surprising agreement and warrants us in taking the value obtained as the most accurate of all. Notwithstanding the elaborate execution of these experiments serious discrepancies exist between the results of the two methods. The latest discussion by Cornu of his own results gives as the most probable value of this constant 300,130 meters, while the values of Michelson and of Newcomb are 299,853 and 299,810, respectively. This makes the error of the results by the two methods ten times the error between those of the same method. This difference has given rise to the impression that in the one or the other or in both methods a systematic error exists and the discussions and corrections made by different critics have left the problem in a somewhat uncertain state. The relation of these determinations to the absolute velocity in air at the earth, and to the absolute terrestrial velocity in vacuo and the possible difference from the velocity in space, renders the problem of great interest and importance in this aspect alone. The famous theory of Weber of moving charges to explain the action of electric currents, while incompatible with the principle of the conservation of energy, has done much to enlarge our views of the origin of electrodynamic phenomena and to establish a comprehensive theory of present phenomena. The brilliant experiment of Rowland as a natural sequence of Weber's theory demonstrated the electromagnetic reaction of a moving charge and showed further that if the velocity were that of light the mechanical reaction would be approximately that calculated from

theory by using the value of the light constant as the ratio of the two units.

The prediction by Maxwell that light was an electromagnetic disturbance in the medium surrounding an oscillating charge, and the consequent identity of the velocity of light in the ether alone with the ratio of the electrical units in the two systems of measurements used, when a charge is respectively in motion or at rest and the further relation of the light constant to the dielectric constant for ponderable media, have been since fully confirmed by exhaustive experiments. His interpretation of the physical significance of the ratio of the electromagnetic unit to the electrostatic unit as a velocity of the same magnitude as that for light received remarkable confirmation in the independently conceived experiment of Rowland already referred to.

The celebrated experiments of Hertz on electric oscillations and the identification of the velocity of their propagation in the ether with that of light waves constitute perhaps a more remarkable instance of the confirmation of a brilliant conception than that of the law of gravitation itself.

If we accept these facts as confirming the supposition that light is an electric phenomenon, then we may consider the results found as data obtained by different methods for the solution of the problem, the velocity of light. It would be necessary then to examine the principles of the methods involved to determine what phase of the problem each corresponds to, *i. e.*, whether to a group-velocity or to a wave-velocity.

Consider first v, the ratio of the two units. In the derivation of the equations for the propagation of undulations in a non-conducting medium the time rate of change in the polarization, either electric or magnetic, is obtained in terms of the line integral of the force, magnetic or electric respectively, around the bounding curve through which this polarization or flux takes place. Since now each term in the resulting equations may be expressed in either the electrostatic or electromagnetic units, the integral of these differential equations would show some connection between the constant in the problem and the ratio of the units, if different units are used, otherwise not. The well-known solution of these so-called wave-equations is a wave-potential involving as one of its factors a function periodic in time and in space. If we follow any value of the function, *i. e.*, the same phase of the disturbance, the distance we shall have gone in a unit of time is found to be the number of electrostatic units in the electromagnetic unit multiplied into the reciprocal of the square root of the constants of electric and magnetic polarization, respectively. In vacuo these constants are unity. We therefore conclude that the value of v is the wave-velocity of light and not the group-velocity.

In the experiment for measuring the velocity of propagation of electric oscillations or Hertzian waves, the frequency of these oscillations is determined either directly, by observing the successive discharges in a rotating mirror, or by calculations from the capacity and induction of the electrical system. By determining the wave-length of disturbance—usually by noting the nodes of standing waves along a wire—the velocity is found. The velocity may also be measured by noting the time for the transmission of individual disturbances over a given interval of space. These methods all have to do with a phase of the disturbance and not with the mean of a group of oscillations, and hence correspond to the wave-velocity.

The electrical methods then all give the wave-velocity, while the optical methods

thus far used do not give directly the wave-velocity or the velocity of the individual disturbance, but a velocity dependent on that of the group.

While the agreement between these electrical constants and the light constant has perhaps been the strongest factor in the identification of electromagnetic and optical phenomena, additional discoveries now give incontrovertible evidence of the common agency of the two classes of phenomena, so that these constants may now be considered with good reason to be, not so valuable as evidence of like phenomena, as independent data in determining the true value of the velocity of propagation of the medium for electrical and optical disturbances. It is true that exact quantitative evidence is lacking. The experiment of Rowland is essentially qualitative, and although his results agree approximately with values calculated from theory, more exact results are extremely desirable, although such a possibility seems to transcend present mechanical attainments. The futile attempts to definitely establish by direct experiments the electrodynamic relations between electric charges and the electromagnetic field do not disturb our confidence in the truth of the theory.

Experiment still fails to give us a mechanical reaction on a charged particle moving in a magnetic field. It fails also in giving a positive reaction on a charged particle when the magnetic field is varied. The experiments to detect the electromotive intensity produced by the variation of the velocity of a moving charge have not yet been successful. These are all essential features of the electromagnetic theory and undoubtedly will receive a successful solution in the future. On the other hand the action of a magnetic field in affecting the discharge in a vacuum electrode tube and the celebrated discovery by Hall designated as the Hall 'effect,' are evidence of the reality of the mechanical action on a charge moving in a magnetic field. The phenomena of discharge, in electrodeless tubes in the presence of electric oscillations is significant of the mechanical action on a charged particle in a varying magnetic field. The discoveries by Faraday and by Zeemann—as we now interpret the association of electrical charges on matter as evidenced by what we know from electrolysis—are a further confirmation of the mechanical reaction of a field of force upon moving charges. The experiments of Lecher on the magnetic action of displacement currents in a dielectric also confirm our ideas in regard to the essential characteristic of an insulating medium and the electric charges on the ultimate elements of matter. Hence we are with full reason bound to identify these constants, and may therefore examine their derivation by a closer analysis of their real significance. If on the optical side the problem of the velocity of propagation of individual disturbances has never been attacked directly, there seems to be full reason for doing so in order to complete the evidence from the standpoint of light phenomenon which we already have at hand on the electrical side.

It would be desirable to determine the velocity of a group of periodic electric disturbances under varying conditions in order to compare it with the velocity of a single disturbance.

In the methods of Fizeau and of Foucault, which are the only ones used thus far, the time of the 'go' and return of a flash of light is measured. The relation of this time to that of the time of the 'go' and return of a single one of the component waves is not a relation at once simple and evident. No experiments have been directly carried out to determine this relation in optical media. We have the-

oretical considerations of analogous examples to go by, but no direct experimental data. Lord Rayleigh has considered the problem. It has been noticed that in the progress of a group of waves in water, the individual waves appear to advance through the group and die away at the anterior limit. Stokes has explained this by regarding the group as formed by the superposition of two infinite trains of waves of equal amplitudes and of nearly equal wave-lengths advancing in the same direction. The mathematical formulation of this phenomenon as thus explained gives a resultant periodic motion with a periodic amplitude varying from zero to the sum of the two elements. The velocity of this maximum, which is called the group-velocity U is related to the wave-velocity V by the variation with respect to the wave-length λ. If the wave-velocity V is definitely known as a function of the wave-length, then the group-velocity can be ascertained. On the other hand, we cannot determine the wave-velocity V from a complete knowledge of the function U. It is necessary that we know the relation of V to the wave-length. Rayleigh finds that $U=(1-n)V$ if the wave-velocity V varies as the nth power of the wave-length λ. Thus for deep-water waves $n=1/2$, $U=3/2V$. In the case of aerial waves U and V are nearly the same. In this instance the ear detects the periodic variation of the resultant amplitude as beats which are propagated out with the velocity of the component waves. The resultant of two such systems of light waves may be illustrated by the interference of the two sodium lines in Newton's rings and the periodic variation in the luminosity of the rings when a great number are examined together. This of course is the fluctuation which occurs in the resultant radiations propagated into space but not capable of being seen by the eye.

The argument from the kinematical point of view for the relation of the two velocities is not entirely beyond criticism as this requires a gradual variation in the amplitude according to the cosine law. As the group sent out by either of these two methods must deviate considerably from this law, it would be necessary to include a number of harmonics in Fourier's series to give the proper configuration to the group. In order that we may then use the kinematical argument we must assume these harmonics are rapidly frittered down and that they never return. This may have some significance in the toothed-wheel method, where some observers have noted a coloration of the return image. Further analysis of the kinematical problem is necessary before we can feel sure of its application to the physical counterpart. The argument which Lord Rayleigh has advanced, based on the consideration of the energy propagated, assumes absorption due to a frictional term proportional to the velocity. Now while absorption in ponderable media is explained on the assumption of imbedded particles in the ether of some specific period, it has not yet been proven that this is the only way in which absorption may take place. If there be absorption in the ether itself it is not easy to see just how it does occur. On the assumption already made above it would be impossible for the ether to transmit waves of certain frequencies corresponding to its natural period and we should have selective absorption, a condition quite contrary to the conception of such a medium. On the above assumption, however, the ratio of the energy passing a given point in a unit of time to the energy in the train after this unit of time is the ratio of the group-velocity to the wave-velocity. Thus we see the ratio depends directly on the amount of absorption. It is not quite clear,

however, that this relation would hold for absorption by some other mode. We may then feel some hesitancy in accepting this relation of the group-velocity to the wave-velocity as based on either the kinematical analogy or the energy argument. We must therefore fall back for the solution upon direct experimental means. The significance of such an experimental solution to the problem of the propagation of undulations should not be underestimated. Investigations of these two velocities for monochromatic light, such as from cadmium or mercury, in highly dispersing substances like carbon disulphide or alpha-monobromonapthaline or dense glass of Faraday, now seem entirely possible and sufficient for the solution of the problem.

In the case of the ether the arguments which can be advanced in regard to velocity of light for different colors indicate the same velocity for all colors. It was pointed out by Arago that any difference in velocity should produce a coloration in any luminous body in the universe which should vary rapidly in intensity. Thus in the observations on the eclipse of Jupiter's satellites they should momentarily show at the instants of disappearing and reappearing a coloration complementary in the two cases. Nothing of this kind has been recorded. Again in the case of Algol, Newcomb estimated, from its probable distance, —greater than 2,000,000 radii of the earth's orbit and the time for light to reach us, 30 years—that a difference in time between the blue and the red rays of one hour would give a difference in velocity of four parts in a million. In the remarkable changes in Nova Persei last year, its complete spectrum appeared to be visible even though the changes in its intensity were far more rapid than in the case just mentioned. As no trace of coloration has ever been observed this difference of time cannot exceed a fraction of an hour. It should be mentioned, however, that in the experiments of Young and Forbes, the velocity of blue light was apparently about 1.8 per cent. greater than that of red light. Both Michelson and Newcomb claim that this would have been very distinctly observed in their experiments with the rotating mirror in the spreading out of the image of the slit into a distinct spectrum. A further instance is cited by Lord Rayleigh which may be of value. If we examine the position of the bands in the spectrum of glowing gases, we find certain harmonic relations. Now if these rays had different velocities in the free ether the position of the bands would be affected and the harmonic relations, apparently holding as deduced from the spectra observed, would not give the harmonic relations in the radiants themselves; or, *vice versa,* such harmonic relations between the radiants would not give harmonic distribution of the bands in the spectrum. From another standpoint it may be mentioned that on any theory of an optical medium we know that either a difference in velocity or a dispersion requires incomplete transmission. This may be due to internal reflection or to transformation into heat. The transmission would also be differential. Thus only a part of the light of the distant stars would reach the eye and this would be more and more colored as the distance increased, due to the differential transmission. No effect of this kind can be observed even in the nebulæ which are so remote that the telescope cannot resolve them, although the spectroscope gives us unquestioned evidence of their stellar nature.

These arguments from the astronomical point of view are, however, uncertain and indirect. Until we can determine to a close approximation the wave-velocities of different colored rays in ponderable media as

well as in the ether, we cannot be assured that we are entitled to consider the determination by the group methods used heretofore as sufficient to give us the absolute velocity of light. Even if we regard the evidence from astronomical observations of the common velocity in space for all colors, and from this conclude that the absolute velocity is the group-velocity, as the equations of Lord Rayleigh show with the assumptions he makes, we are still lacking sufficient data for the relation in the case of ponderable media.

In the discussion of the results by the toothed-wheel method and the rotating-mirror method, considerable difference of opinion has been expressed as to just what we obtain by the latter method. There seems to be no dissenting opinion that the toothed-wheel method gives the group-velocity directly, for here we have the time of transit of an interrupted beam of light. In the rotating-mirror method the ray is also intermittent. Lord Rayleigh seems first to have raised the interesting question as to what is actually measured in these experiments, and in his first note states that the rotating-mirror method gives the group-velocity U. In a later article he arrives at a different result and gives the square of the wave-velocity divided by the group-velocity, V^2/U. Evidently unless we know the relation of the two we can find neither if this be correct. Now this relation is not certainly known as pointed out above. On the other hand Gouy, however, dissents from this second view and shows that the group-velocity U is the quantity determined by the rotating-mirror method. Schuster in a later article dissents from Gouy's conclusion and corrects Lord Rayleigh's second result, and gives the square of the wave-velocity divided by twice the wave-velocity minus the group velocity, $V^2/(2V-V)$. J. Willard Gibbs in a later article points out an error in the derivation of this relation by Schuster and shows that the group-velocity is after all what is determined by the rotating-mirror method. He shows further that the results of Michelson's observation on carbon disulphide give a closer agreement with the refractive index with this conclusion than with the conclusion arrived at by Schuster. Lord Rayleigh suggests in his second note that by placing a lens in the path of the ray so that the fixed mirror is at its focus the rotation of the wave-front caused by the rotating mirror would be corrected on the return and we should thus find the absolute velocity V. This is evidently in error, as Schuster showed, as the rotations would be added. Even if neutralized we should not obtain V, but U. In a reply to a communication by the writer to Lord Rayleigh in 1890 as to such a method for the absolute velocity he has indicated a misapprehension on this matter and expressed his opinion as to the probable correctness of Professor Gibbs's conclusion which agrees with his first position. With the exception of Schuster the rotating-mirror method seems to be accepted by all as giving the group-velocity. The correction for the rotation between two successive wave planes which is erroneously given by Schuster would give the group-velocity and thus an agreement with the results of the rest. While the observations of Michelson on carbon disulphide give the closest agreement with this result, more exact data for specific wave-lengths are desirable in order to confirm the theoretical conclusion.

In studying the question of group and wave-velocities in connection with dispersion the following two methods occurred to the writer: The first one was for increasing the sensibility of the old methods, and the second one for observing the wave-velocity directly by means of interference. In 1889 he was invited by President Hall to Clark University to conduct, among other things, an investigation on some special problem.

The dispersion in air was selected, and a combination of the arrangements of both Fizeau and Foucault which had occurred to the writer before was adopted. The essential condition in Fizeau's method is to produce an intermittence in a beam of light. This is done mechanically by the rotation of a toothed wheel.* It is quite clear that if the wheel were fixed and the ray rotated the condition of intermittence would be fulfilled. It would then be merely a matter of arranging a suitable optical system to maintain a fixed direction for the ray while in transit between the two stations. Any such optical system would avoid the inertia inherent in a mechanical system and would thus allow of much greater speed and consequent sensibility. Through the courtesy of the Secretary of the Navy and the active assistance of Professor Newcomb, the photo-tachometer of the latter was secured to carry out this experiment at the University of Nebraska instead. This instrument seemed to be well suited for a preliminary experiment on account of the rectangular shape of the rotating mirror and the number of reflecting faces available. Figures 1 and 2 show the arrangement used and the path of the ray. The original apparatus was changed slightly, the two telescopes T and T' being shifted so that their axes passed through the middle of one set of faces when these stood at 45° to the same. The other additions were the lens L the grating G and the plane mirror M. The instrument was originally mounted so as to use the concave mirror belonging to the instrument itself, which had a radius of curvature of 3,000 meters. Owing to improvements about the campus it became necessary to remove the piers and discontinue the experiment for several years. It was again finally mounted in the basement of the Physical Laboratory on a much smaller scale and the flat mirror M used at a distance of about fifteen meters from the rotating mirror R. The lens L was a telescope lens of one meter focus and ten centimeters aperture. The concave mirror G had a radius of curvature of one meter and

Fig 1

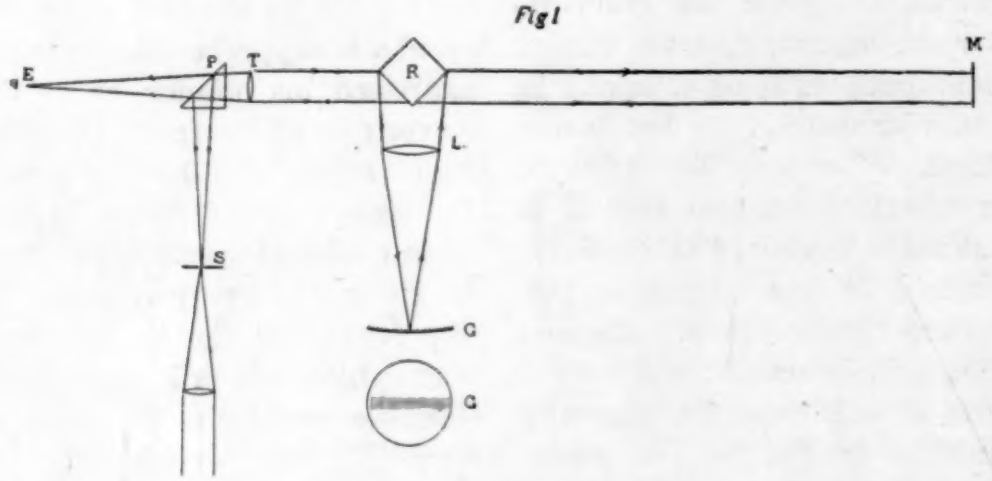
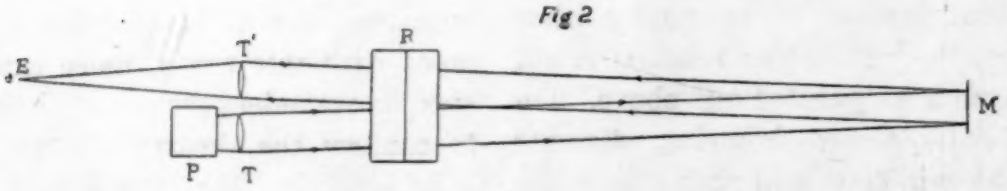


Fig 2



* In the March number of the *Philosophical Magazine* for this year, Professor Michelson describes a similar arrangement which occurred to him independently during his experiments on the motion of the ether.

an aperture of ten centimeters. A narrow strip across this mirror was divided into equal bright and dark spaces of ten to the millimeter. This was accomplished by means of a diamond making five deep strokes in each alternate space. In this way normally incident light would be returned over the same path from the bright spaces, but be scattered from the cuttings in the adjacent spaces, so that very little of it would be returned in the direction of incidence. A lens converged the sun's rays on the slit S from which a beam passed to the mirror P through the collimator lens T to the upper part of the adjoining face of the rotating mirror R from which it was reflected at 45° through one quarter of the lens L and brought to a focus on the grating mirror G. From this it was reflected through the lower opposite quarter of the lens to the lower part of the next face of R and thence reflected at 45° to the plane mirror M as parallel light. This reflected it to the upper part of the same face of R thence through L to G and back to the lower half of the face of R upon which it was first incident and thence through the observing telescope T' below the collimator, to the eye. It is clear from the diagram and from the principle that an even number of reflections of a ray system from a moving reflecting system does not alter their direction that the incident and the reflected rays from the rotating mirror R will remain parallel to each other and hence will always meet the mirror M at the same point during the rotation of R. For the moment let us assume the image of the slit S just covers one of the bright spaces. By proper adjustment of M the return image can be made to coincide with it. Usually it was displaced slightly below it so as to observe the relative positions of the two when the mirror R was rotated so as to carry the images across the grating. If now, during the time of transit from G and back, the mirror has rotated through an odd number of spaces no appreciable light will be reflected from G through T' to the eye. If the rotation corresponded to an even number of spaces, the eye would see an enfeebled image of the slit S. If the mirror were varying in speed the eye would see this image pass successively through maxima and minima, depending on the rate of change of the rotating mirror R. Suppose now the image of S covers any number of spaces on G the eye will see an image of S, but crossed by bright and dark spaces corresponding to those on G. With the corresponding variations in the speed of the rotating mirror the eye will see corresponding fluctuations in this image. In this way the eye may be able to determine the minima by comparison with the darker spaces which remain of constant intensity.

The aperture of the 'sending' telescope was 4.5 cm. but the effective aperture with the rotating mirror at 45° was only 2.5 cm. The actual spacing was .02 cm. between the bright lines, which is well within the limits of good definition. The mirror could be driven up to 250 revolutions or more per second without serious vibration. Thus the ray could be interrupted about 10,000,000 times in a second. This would give a group of waves about fifteen meters long. If the limits of resolving power and speed were used 40,000,000 interruptions could be obtained and the length of the groups could be reduced to less than four meters. Thus there would be about 6,000,000 waves in each group. As the eye can observe a change in intensity of less than one per cent., the method would thus be capable of detecting the existence of a velocity if the total distance of the mirror M were less than 2 cm. from the grating. This shows the sensibility which the combination of the methods of Fizeau and Foucault may give under very favorable conditions.

If the velocity were different for differ-

ent colors this method would be capable of showing even a very slight difference. For example the difference in velocity between the extreme red and the violet rays in carbon disulphide is about one sixteenth. For air this difference is about one part in one hundred thousand. Now an addition of five per cent. of one of these colors and a subtraction of the same amount of the other from white light will produce a perceptible change in the time. Thus if we consider a five per cent. change instead of one per cent. as mentioned previously, and multiply this by sixteen we obtain 1.6 meters as the length of a column of carbon disulphide between the grating and the fixed mirror, in which we could just detect the dispersion of light. Similarly in the case of air we have to multiply by five and by 100,000 and obtain about ten kilometers to produce the necessary dispersion in air. It is very doubtful whether this sensibility can be actually realized. In the preliminary experiments with his instrument sunlight was used. The scattered light from different parts of the system prevented the contrast between the light and dark spaces in the return image which would be necessary for such a high sensibility. By adjusting the mirror M so that the images of the bright spaces of the grating should fall on the dark spaces on their return, the appearance for an eclipse could be studied. In reference to the intensity of the return image, if we allow fifty per cent. less from successive reflections and remember that the angle of the grating was only one sixtieth of the circumference, we find only about one per cent. of the light available in the return image. Thus with the mechanical system of Fizeau's toothed wheel we should have one hundred times the light available for the same aperture. The preliminary experiments were made under unfavorable conditions, but indicated a greater sensibility than that heretofore obtained. With sunlight sufficient intensity would be available for the experiments just referred to. With the apparatus as mounted too much instability was experienced to obtain satisfactory definition with the rotating mirror and the motor and blower which drove it in motion. The condition of the faces of the rotating mirror also prevented distinct definition. In order to use all four faces they required refiguring and the angles between them recut. The lack of funds to make these changes and the recall of the instrument have caused the experiments to be interrupted several times and finally abandoned until the means for building apparatus more suitable for the purpose and for carrying out the experiment can be obtained. This method will give the group-velocity U directly according to the criticism already referred to on the method of the rotating-mirror. The possibility of obtaining important data on group-velocity in different media by so sensitive a method, and also the determination of the velocity of light in a vacuum itself warrants further efforts being made along this line. These experiments were initiated in 1889 and discontinued a half dozen years later in the way mentioned.

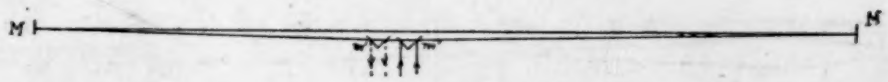
It is doubtful whether there are other methods for determining the group-velocity of greater sensibility. One method of considerable promise is by means of polarized light. Two rays of light pass through a Nichol and a half-wave plate. Each is reflected from each of two mirrors respectively. By properly focusing we should have a half-shade combination which on rotating the half-wave plate and the Nichol about the common axis would give a difference in the intensity of each return ray. Half-shade systems have a sensibility as high as one thousandth of a degree in the

limit. Such a Nichol could probably be rotated at a speed exceeding two thousand per second. Polishing machines are now run above one hundred thousand a minute. Foucault's mirror rotated eight hundred times a second. At such a speed and sensibility a velocity in light could be detected over a distance of about twenty centimeters.

Another system depending upon electric oscillations would require much the same optical system. A prism of glass between two electrodes as arranged for the Kerr 'effect' in a dielectric is placed beyond a half-wave plate and a Nichol prism which is fixed. If now the glass is subjected to electric strain by rapid oscillations, the fields from each mirror are lighted up differently and the limiting distance at which this difference is observable will be the same as stated previously. Probably oscillations several hundred millions a second would be possible with such a condenser system. Forty millions a second was the limit with a rotating mirror and grating as described above. This could probably be increased to one hundred millions a second with a suitable rotating mirror. Instead of using the Kerr 'effect' a piece of Faraday glass within a single turn of foil could be used for very high frequencies and the Faraday 'effect' employed instead. Probably the same order of sensibility could be obtained as with the former. It is hoped to make preliminary experiments on these promising methods which would probably give shorter groups or types of waves than any of the others. Here we should have not an intermittence but a property impressed at intervals upon a continuous train of waves, and the relation of the velocity of that property to the wave-velocity would have to be determined.

No method for determining the wave-velocity of light seems yet to have been proposed. The following arrangement occurred to the writer in 1890 while experimenting with the phototachometer as already described. Suppose that in two interfering systems of rays we could alter the length of the path of one or both of the rays during their transit from their common source to their final point of meeting, there would be a displacement of the bands depending on the relative retardation introduced into the paths during this interval. Figure 3 illustrates the first conception of the system. A beam of parallel light, from a lens, say, strikes the two adjacent faces

Fig 3



of a rectangular mirror, each face of which reflects the rays in opposite directions to the mirrors M and M', each of which reflects the corresponding rays to the other and thence both return to the mirror, thus traversing each other's paths. If now the mirror m is displaced to the position of m' in this interval the path of one ray will exceed that of the other by twice the distance through which the mirror has moved. Knowing this distance, by means of the wave-length and the time it takes to displace the mirror a given distance, we have at once the time of displacement of the mirror from the position m to m' and thus the time of transit of any one ray around this path, and hence the wave-velocity. Considerable difficulty was experienced in devising a method of displacement of sufficiently high speed. If the mirror m is mounted on a rotating disc the rays would be reflected beyond the mirrors M and M' and the interference would be changed by

the angular motion of the mirror. The mechanical oscillator of Mr. Tesla suggested itself as capable of giving possibly sufficient speed. The variation in the speed which would cause the bands to be superimposed and thus obliterated rendered this method impossible. The same difficulty would be experienced with any reciprocating means. The compensation for angular movement of a disc did not seem clear and its use was abandoned for a time. Instead of this the system indicated in Figures 4 and 5 was tried. L and L' are

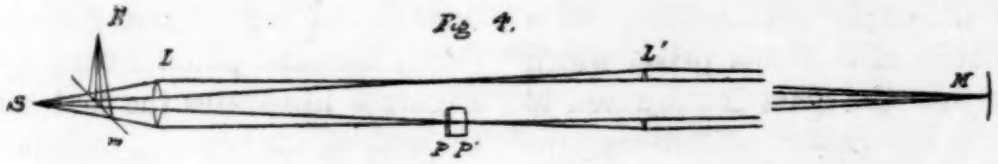


Fig. 4.

Fig. 5.

two bisected lenses, P and P' two prisms, one of which, P', is mounted on a rotating disc so that the total thickness would be increased or diminished by its rotation. The split lens L forms two images of the beam from the slit S and one half of its aperture. In one focus the double prism is placed. The split lens L' forms coincident images on the distant mirror M, which reflects each ray back over the path through the opposite halves of the lenses to the mirror m, which reflects the light to the eye. If now the prism P' be moved in the interval of transit of this optical circuit the ray returning through it will be retarded over the other. Knowing the constants of the prism and the speed of the disc we can calculate, in this way, the wave-velocity. The interference bands in this system remained distinct during the movement of the prism over an arc of five to ten degrees. The length of this system in the preliminary experiment was about thirty meters. With sunlight and a much greater distance, distinct bands could easily be obtained with only one fiftieth the intensity, which represents the fraction of the incident light available during one revolution. Here again we are met with the difficulty of obtaining an insufficient component velocity in the direction of the ray, which is the velocity of the disc into the cosine of the angle of the prism into the index of refraction less one.

Through a fortunate idea the rotating disc was made possible and the final and most serious difficulty was overcome. Figure 6 gives the arrangement with somewhat distorted details to show the optical relations. The principle that an even number of reflections in a rotating system does not change the relation of the incident to the transmitted ray was made use of. A further difficulty had to be met in maintaining the ray upon the reflecting elements, as the rotation of the reflected ray is twice that of the reflector. If the radius of rotation is reduced one half the linear movement of any point is reduced one half. These considerations applied to two mirrors on the rotating disc met the required conditions. Thus the mirror m is placed just half the distance of the mirror m' from the center. A ray incident upon m is reflected to m' and thence reflected in some definite direction. If the disc now rotate, the ray will rotate through twice the angle, but still strike the mirror m' in the same point if

these conditions are fulfilled and will be reflected off parallel to its former direction. This relation will be maintained as long as the above conditions hold, which will be, approximately, through a considerable fraction of the circumference. This will be best satisfied when the mirror m is normal to the radius, the incident ray being thus nearly normal. The arrangement as finally adopted is shown in the figure. Light from the slit S is converged by a lens L to a half silvered plate I, one beam being reflected and the other passing through and being reflected by the mirror I'. Both converging beams strike the mirror m at the same point and are then reflected, the first beam to the adjacent face of the rectangular mirror m' and the second to the opposite face, where they form images of the slit S. The first beam is reflected to M' then to M and finally to a focus on m', while the second ray passes over the path of the first to a focus on m'. Thence the two rays trace each other's paths and are reflected and transmitted respectively by the plate I through the spectral system P to the eye, where interference bands are formed. Thus, aside from other losses by reflection, one fourth of the light reaches the eye. The distant mirror M may be concave and of the proper focus for the system; or two lenses I and I' may be used so as to obtain a greater aperture to the beam. These two rays will in general travel over slightly different paths and hence give bands which may be conveniently analyzed by means of channeled spectra. If now the disc rotates the path of one of the rays will become greater than the other and the interference bands will shift. If a spectrum is used the bands will move across the field, increasing or decreasing in number. If the adjustment is initially made so that the paths are the same, no bands will appear until the disc is set in motion. By counting the number passing any point we can obtain the order of the interference for that wave-length, and from the dimensions and speed of the disc determine the wave-velocity for that color. From the position of the other bands at this instant we can calculate the velocity of that color. Thus we have the means at hand for obtaining the wave-velocity for all colors, from which the group-velocity for the same can at once be obtained. The radius to the disc m' is 15 cm. and a speed of 500 per second is assured. The concave mirror M has an aperture of

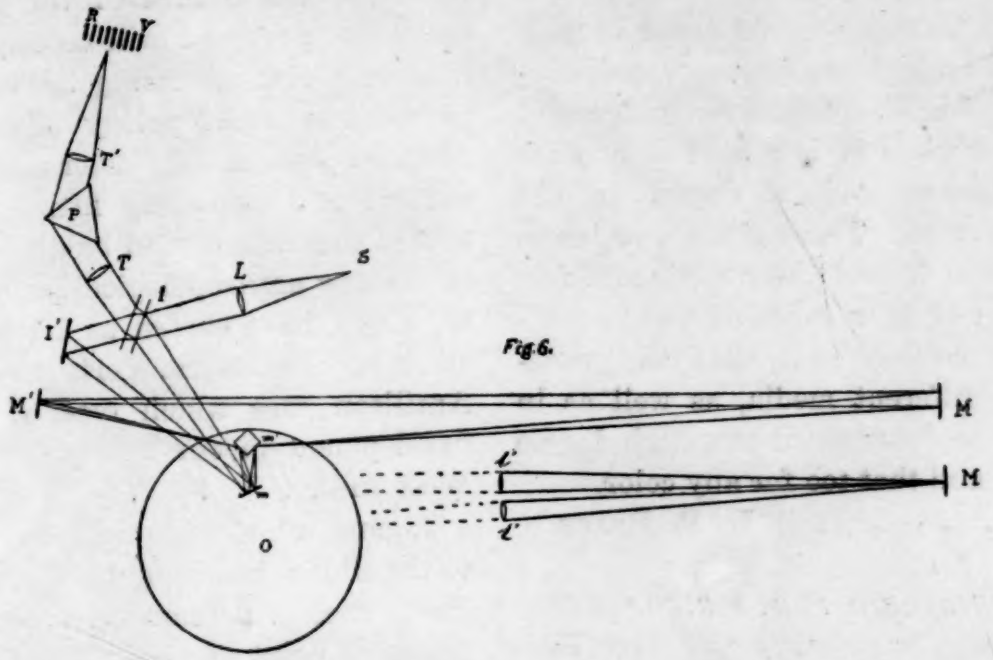


Fig. 6.

15 cm. and a radius of curvature of 15 M. This is the arrangement now being used. With this velocity, assuming a band can be read to one thirtieth part, a distance of only .3 cm. would show a velocity. The rays during transit may be made to pass within a tube which can be evacuated, connecting M and M'. Another arrangement may be used when M is placed at a much greater distance and is shown in the annexed diagram. I and I' are two lenses whose foci are M and their conjugate foci on each face of M' respectively.

It seems certain now that the wave-velocity in different media, as well as in vacuo, may be determined to a high degree of accuracy and that too for any color.

University of Nebraska. D. B. Brace.

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*PREHISTORIC PORTO RICO.**

It has been customary for the Vice-President of this Section of the Association to present in his retiring address certain general conclusions to which he has been led by his own special studies or those of his contemporaries. But it has not been regarded as out of place for him to outline new and promising fields of research or to indicate lines for future development of our science.

Late historical events have brought into our horizon new fields for conquest and opened new vistas for anthropological study. In the last years the political boundaries of the United States have been so enlarged that we have come to be regarded a 'world power,' and with this growth new colonies beyond the seas now form parts of our domain. With this new epoch certain broad scientific questions have come to present a special claim on our students, and we have been brought closer than ever before to problems concerning other races of man besides the North American Indian. Great fields of work attract our ethnologists to the far East and the islands of the Pacific, and these new problems will occupy our attention with ever-increasing interest in years to come as anthropology advances to its destined place among sister sciences. It is natural and eminently fitting that attention at this time should be directed to some of the new anthropological problems before us, and I have chosen as a subject of my address, 'Prehistoric Porto Rico,' and the Antillean race which reached its highest development in our new possession in the West Indies.

Among all the acquisitions which came to the United States by the Treaty of Paris, Porto Rico is preeminent from an anthropological point of view. Fourth in size of the Antilles, it is the most centrally placed of a chain of islands reaching from Florida to the coast of South America. Before the coming of Columbus there had developed in these islands a culture sufficiently self centered to be characteristic, and our new possession was the focus of that culture. Here was found a race living in an insular environment exceptional on the Western Hemisphere. If as the great anthrogeographers insist anthropological problems are simply geographical in their final analysis, where can we find a better opportunity to trace the intimate relationship of man's culture and his surroundings? Where was there on the American continent at the time of its discovery a people less affected by contact with other cultures or more truly the reflection of climatic conditions?

It may be truly said that important questions regarding migrations of the early inhabitants of the American continent are intimately related to the cultural character of the prehistoric race which

* Address by the Vice-President and Chairman of Section H, for 1901, at the Pittsburgh meeting of the American Association for the Advancement of Science.

peopled the West Indies. Was this race derived from the great northern or southern land masses or was it an offspring from the early inhabitants of Yucatan, the great peninsula of Mexico which projects towards the end of Cuba? Many theories of the peopling of these islands have been propounded, but none is regarded with full confidence. Although this race was the first seen by Europeans, by whom it has been known for the longest time, comparatively little accurate study has been given to it by the anthropologist. Documentary evidences are not meager, but ethnological data are limited, for the race disappeared within a few generations after its discovery and lost much of its distinctive characteristics by mixture with other peoples. Archeology furnishes more material bearing on the problem than ethnology, but this material has not been correlated, being widely scattered in different museums in Europe and America, and in collections which remain in private hands. A great amount of archeological data yet remains hidden in the soil awaiting the spade of the explorer.

Although English scientific literature on the archeology of Porto Rico is remarkably limited, the study has attracted several anthropologists whose works are of highest importance. It has been zealously cultivated by several native Porto Ricans whose publications, in Spanish, are little known to students in the United States, since some of the most important of these contributions have appeared in local newspapers of the island having no foreign circulation. The main sources for the more important historical works of modern historians are standard writers like Oviedo, Herrera, Muñoz, Las Casas, and Iñigo with notes by J. J. Acosta, and rich unpublished documentary material by Tapia y Rivera. The more prominent modern Porto Rican historians are Salvador Brau and Coll y Toste, who deal more especially with historical epochs, while the writings of Padre Nazario, Neuman, Gandia and Torres, many of which are controversial, are important aids in the same lines of research.

No institutions have exerted a more stimulating influence on the local study of Porto Rican history than that of the 'Socieded Economica de Amigos del Pais,' and the Ateneo Puertorriqueño of San Juan. The former, founded by enthusiastic students in Europe, no longer exists, but the latter has a fine library on the plaza Alfonso XII. where there are a number of portraits of famous Porto Ricans.

A most valuable scientific publication, on the Indians of Porto Rico, and the only modern Spanish work which follows archeological methods is by Dr. A. Stahl, a native of the island, educated in Germany, who has made many important contributions to the study of the flora and fauna of the island. This work, 'Los Indios Borinqueños' appeared in 1889 and while criticised in unessentials has held its place as a work of highest merit.

Professor Mason's catalogue of the Latimer and Guersde collections are the most important archeological works which have yet been published on the antiquities of the Antilles. There are many scattered references in the writings of Stevens, Dr. Cronau and other authors which augment this information and practically complete the all too meager literature of a great subject.

It would be impossible for me in this brief address to do more than outline in a general way the prehistoric culture of Porto Rico. I have in preparation a more extended account in which I have drawn largely from sources above mentioned, from an examination of many archeological specimens in private collec-

tions unknown to science, and a personal study of the island on a short reconnoissance in April and May of the present year.

Ethnology affords us but scanty data for the study of the subject, as the aborigines have been so changed by intermarriage with other races that little can be identified as belonging to the precolumbian life of the island. Still in the more isolated regions the Indian features can be recognized and certain customs peculiar to the island can be traced to Indian parentage.

There are many Boriquen words in the patois of the mountainous region, and the rugged valleys of Loquillo, the Sierras on the eastern end of the island, called Yunque and Cacique mountains, still have a wealth of folklore, part Spanish, part Indian, with a mixture of African, which will reveal to the folklorist many instructive phases of this subject. Mr. Spinosa has already published some of these tales in a short popular account, but much in this line yet remains to be done in this isolated, perhaps the most inaccessible region of the island. Many of the mountains in this locality are regarded as enchanted and about them cluster stories of St. John, the patron of the island, mixed with legends of old Indian caciques and their families.

In his note on the name of the mountain Yunque, Acosta, quoting from a documentary account of Porto Rico by Presbiter Ponce de Leon and Bachillar Antonio de Santa Clara, written in 1582 by order of the King, derives the word Loquillo from the name of a cacique who lived in this high Sierra but was never conquered. According to Acosta this tradition of the last surviving cacique of the island has furnished a subject to Sr. Tapia y Rivera for his novel entitled 'El Ultimo Borencaño.'

All the available evidence supports the conclusion that we must look in the inaccessible region of Porto Rico called Loquillo for the purest Indian blood among the present mountaineers of the island. In the isolated valleys of this region we still find the old Carib canoe surviving in the hollowed-out log of wood by which produce is drawn down the slippery mountain sides. Here are also the old forms of hammocks different from those now generally used. Maize is a staple article of food and the primitive mills with which it is ground date back to a remote past.

The prehistoric inhabitants of the Antilles from the Bahamas to the coast of South America belonged to one and the same composite stock differing in minor characteristics which are not racial. The people of the Bahamas, Cuba, Hayti and Porto Rico are a mild agricultural race which had lost in vigor what they had gained by their sedentary life. The Caribs confined to the Lesser Antilles were more warlike and their ferocity was known everywhere in the West Indes. Columbus heard of them on his first voyage when he landed on the Bahamas, and on his second voyage his first landfall was on one of the islands where they lived. Although he saw little of the Caribs on this voyage, he learned of Boriquen or modern Porto Rico from some of the captive women, and taking these slaves on board his ship, he coasted along its southern shore, at last landing on the western end, near Aguadilla, filling his water casks at the famous spring at that place.

Although a well-known local historian has questioned this as the landing place of Columbus in Boriquen, the evidence supports tradition and a beautiful monument very properly marks the place where the great Admiral landed in 1493. But while the majority of writers ascribes the discovery of Boriquen to Co-

lumbus, on his second voyage, Sr. Luis Llorens Torres gives the honor to another and, in a well-written pamphlet on 'America,' has shown in a convincing way that when Martin Alonzo Pinzon separated from the great Admiral, on his first voyage, he visited Porto Rico, and probably landed on its shores.

Dr. D. Isaac Gonzales Mestizes, as quoted by Sr. Torres, states very clearly the arguments for the unity of the prehistoric people of the West Indies, and shows that the insular Caribs and Boriqueños were practically of the same stock, although they differed somewhat in their mode of life, due to climatic influences, their religion, customs and languages.

The former although confined to the Smaller Antilles made frequent predatory expeditions upon the more peaceable inhabitants of Cuba, Hayti and Porto Rico, especially the latter, carrying away the women as slaves. Thus we have in the insular Carib communities men and women speaking different dialects, showing idiomatic differences in the Carib and Boriquen speech and implying amalgamation of the two stocks. The incursions of the Caribs on the eastern coast of Porto Rico continued after the Spanish had made settlements there and they raided and destroyed the town Naguabo on the river of the same name.

Unfortunately we have no authentic cranium of a typical prehistoric Porto Rican to compare with that of the Caribs, although it is probable that skulls of this race could be found in a systematic scientific exploration of the island, especially in caves in the neighborhood of Utuardo Ciales and the more inaccessible parts of the island. The name of a cave, Cuea del Muertos, not far from Utuado indicates that it was used for burial or deposition of the dead. These caves contain many religious symbols, as rock etchings of gods and grotesque forms of idols cut out of stalactites, showing that they were used by the Indians as places of worship, refuge, or possibly for burial of the dead.

When Columbus landed on the island of Guanahani the first native words he heard belonged to a language which was one of the most widely distributed of those of the new world, a tongue which, with dialectic variations, was the speech from central South America to the coast of Florida. These dialectic differences in the speech of the Antilles aborigines were small, the Caribs of the Lesser West Indies and the Lucayans of the Bahamas being linguistically of the same stock, as has been repeatedly pointed out by several writers, ancient and modern. This same stock had left traces of its language and peculiar culture on the Spanish main along the coast of Mexico, which facts are significant but have led to erroneous views of the relationship of the aborigines of Central America, Cuba, Hayti and Porto Rico.

The accounts of the houses of the prehistoric Porto Ricans by Oviedo, Iñigo and others are amply sufficient to lead us to conclude that they did not greatly differ from those of the country people today. Stone or adobe buildings were not constructed, but a fragile cabin the frame of which was tied together with maguey fiber and covered with bark of the royal palm or yucca and thatched with straw furnished a home for the prehistoric Portoriqueños. These houses, like their modern representatives, were raised on posts to avoid dampness and insects, suggesting pile-dwellings—a feature of house-construction with which the Caribs were familiar.

In many of the smaller towns of Porto Rico we still find a street lined with these houses built in the same primitive way,

inhabited by poorer people, negroes or peons. Some of these modern buildings are of the rudest construction and practically the same as those which Oviedo described, in Hayti, four centuries ago.

It appears from early records that, at the time of Columbus's first visit, the Indians lived in cabins scattered over the island, but that here and there these primitive dwellings were collected in pueblos. The pueblo of the Cacique Guaybana was described by Muñoz in some detail. It was situated back from the shore and consisted of a circle of these cabins surrounding the central houses of the cacique. Two parallel rows of palisades forming an arbor united this pueblo with a lookout on the beach, built somewhat higher as a place of observation. It is probable that the plaza enclosed by the ring of houses was the dance place, and that the central houses of the cacique contained the clan idol and other objects used in the cult of the inhabitants.

Similar villages are reported as existing in Cuba and Hayti, and it was probably into one of these that the embassy of Columbus to the Great Khan was conducted, when they penetrated into the interior of the former island. On their return to the squadron this embassy reported to the Admiral that they were escorted to a special house, probably that of the cacique, seated on a wooden chair (evidently a *duho* such as we now find in several collections) made in imitation of an animal and surrounded by natives who also had their appropriate seats. The accounts clearly indicate that the Spaniards were regarded as supernatural beings, carried to the god house of the pueblo, and seated on the chair of the gods.

The furniture of the house of the ancient Porto Rican was limited but ample. The bed was a hammock made of the leaves of the palm, maguey or fiber of native cotton. In the mountainous regions of El Yunque primitive hammocks, like those of the ancients, are still made and the palm fiber is wholly employed in their construction. Calabashes or cocoanuts served for household implements as drinking cups, and in the poorer parts of the island are still used for the same purpose. We have every reason to suppose that these objects were ornamented with incised geometrical figures, but whether the patterns now used in the adornment of these objects have been inherited from a Carib ancestry is yet to be satisfactorily made out.

Clay vessels of rude construction were used by these Porto Rican Caribs who lived along the shore. Multitudes of fragments of these objects are found to-day in several localities, one of the best of which is the country about Cabo Rejo. These clay vessels are, as a rule, of rude construction, unglazed, their rims commonly adorned with raised heads representing animals of grotesque forms. The likeness of many of these heads to monkeys has led several writers to ascribe this pottery to races living on islands or the mainland inhabited by simian genera. There are no monkeys in Porto Rico where these heads are found and, as the clay objects are most abundant along the shore, they are generally ascribed to the Caribs. I have examined several unbroken clay vessels from the island which are undoubtedly of Carib manufacture, all of which were ornamented in relief or intaglio, and regard this supposed resemblance to monkeys' heads as highly fanciful.

According to the early writers the men and girls had little clothing, but the married women and caciques wore a woven cloth of palm fiber called *nagua*, which apparently resembled the breech cloth with dependent ends. In the warm climate

clothing was not needed for warmth and a liberal covering of paint protected their bodies from the heat of the tropical sun and the bites of troublesome insects.

The most characteristic of all objects made by the Caribs were the canoes, with which they navigated from island to island or traveled along the numerous rivers and lagoons. These craft often reached a great size and were in some instances made of logs of wood hollowed out with stone tools aided by fire. If there is one feature which more than others distinguishes this Antillean culture it is the development of their maritime habits, of which these canoes are the objective expression, but this characteristic was highly developed before the race landed on the islands. Canoe building had reached a considerable development in their primitive original homes, and made it possible for the tribes to migrate to the islands.

The number of stone implements in collections from Porto Rico is very large, including objects of all sizes and many shapes. The arms of warfare were mostly adzes and hatchets with wooden handles, war-clubs made of ironwood of the island, spears and possibly throwing-sticks. In the collections which were examined, no arrow points were found. As a rule the implements from the Antilles are polished stone, but I have seen two celts which show marks of chipping. Most of these implements were of stone, but Mr. Yunghannis, of Bayamon, has in his collection a celt from Porto Rico made from the lip of a conch shell like those used by the Caribs of the Lesser Antilles.

The height of culture attained by the prehistoric inhabitants of Porto Rico, as shown by their pictography, has been variously interpreted, but, so far as known, the writing of this people was of the rudest kind, consisting of pictures having the same general character as the pictography of the North American Indians. Specimens of this work are found on the flat slabs of stone used in the enclosed dance plazas or on isolated bowlders. The soft, easily eroded rock of the island does not retain this paleography for any considerable length of time, especially when exposed to the weather.

In the caves on the island there still remain many excellent specimens of picture writing, some of the best of which are studied near Ciales and Aquas Buenas in the high mountains of the central region of the island. Some of the caves are of great beauty, among the most interesting of the many natural attractions of Porto Rico. They were resorted to by the Indians for religious purposes and later for refuge, but there is no reason to suppose that they were ever extensively peopled, for the ancient Porto Ricans lived in the open and were not troglodític.

An article published by Mr. Krüg contains all that has yet appeared in print on Boriquen pictography, which will be more fully illustrated in my report on a reconnoissance of the island during the last spring. The figures which were studied appear to be clan totem and other symbols.

From the accounts which have been preserved there is every probability that the social organization of the inhabitants of prehistoric Porto Rico was practically the same as that of the Indians of other parts of America. The unit of organization was the clan, the chief of which was called a cacique.

It would appear that certain of these caciques had control over others, governing large sections of the island, and that a union of several smaller caciques for mutual defense occurred at rare intervals. As a rule there was no such union, caciques of neighboring valleys were not friendly, often hostile, making raids on each other.

In certain sections of the island a Carib chief appears to have raised himself to the position of governor of this region. In every settlement the cacique and his immediate relations occupied a house larger than the others and centrally placed, containing the penates of the clan. The power of the head clan man was supreme, his wives, of which there were many, were practically slaves and descent was apparently in the male line. The cacique had several insignia of his rank, among which may be mentioned bodily decoration, a gold plate, called a *guarim*, worn on his breast, and a stone amulet (beautiful specimens of which are now preserved in several collections) tied to his forehead.

The names of many of these caciques are still preserved on the island, and it would appear that localities, mountains and rivers, were so called after powerful rulers. Thus we have Arecibo, the modern name of a beautiful city on the north coast, in the district of the chief, Areziba, Mayagoex gave his name to Mayaguez, and many other examples which might be mentioned. It is probable, as shown by Dr. Stahl, that the names of minor caciques, possibly clan chiefs, are perpetuated in names of the modern towns Utuado, Yubucoa, Gurabo, Cayey, Camuy and many others. Aguenaba is commonly stated to have been the sovereign ruler of all the island, but his power was certainly not always recognized, and it would be exceptional in Carib society to find one man an absolute ruler of the island of the size of Porto Rico.

Among supposed insignia of caciques should be mentioned characteristic stone ring form, which from their form have been called 'collars.' These are often made of the hardest stone, beautifully polished and decorated, showing evidence of having been ornamented with inlaid gold or precious stones. The interpretation of these objects is one of the archeological enigmas, for the early historians are silent regarding their use or what they represent. The consensus of modern opinion is that they were bandoliers worn by the caciques as insignia of rank, and the form of many favors this conclusion. Others are too small and many too heavy to be carried either about the neck or on the shoulders as a kind of bandolier, which facts throw some doubt on the theory that these objects were ever worn on the person. The older writers are also silent regarding the meaning of the elaborate designs which are cut upon them. A study of these designs on many specimens shows that, in some instances, they correspond to the head and parts of the body of certain stone idols, and there is every probability that these designs represent forms of clan gods. Acosta, in a valuable note to the last edition of Fray Iñigo's history of Porto Rico, refers to his examination of many specimens of these collars and suggests that these rings represent the bodies of serpents upon which stone heads were fitted, the whole representing a coiled serpent.

This is not the place to present all the evidence I have gathered to support this suggestion, but it may be said that in one of the so-called collars which was examined on my recent visit to the island the resemblance to a coiled serpent was so close that its identity was perfect, even the head being well represented.

It may be urged, since snakes are so rare and small in Porto Rico, that the natives would not elevate a cultus of them to the height these stones imply. But it may be said that stone collars of this kind are not confined to this island, occurring also where serpents are large and deadly. Moreover, the old accounts say

the Antilleans had images of snakes and these are the only objects of serpentine form known to collectors. Although it is probable that these problematical collars were sometimes worn as insignia, there are many others where this use would be impossible.

Among the best polished stone images found in collections from Porto Rico are small figures, called amulets, representing frogs, turtles, lizards, birds and other animals. These nicely worked specimens are commonly concave or slightly curved on one side, being tied in position by means of a cord passing through a hole drilled from edge to edge. Some of the writers of the sixteenth century mention the fact that the Antilleans wore stone images on their foreheads, to indicate the clan.

As in all primitive society the social organization of the Antilleans was built on a religious foundation, the people being governed by priesthoods which controlled all the public life of the people. Every cacique was a priest in virtue of his standing in the clan, which was the political unit and, as we shall later see, the religious and ceremonial unit as well. The whole social and religious organization was knit together by a form of totemism or tutelary clan ancients worship which I shall call zemeism.

These priests were called Boii or sorcerers, and their idols apparently often had the same name as the priesthood. In their ceremonies these priests represented ancestors symbolically, and naturally took the names of that which they represented.

The functions of these priests were much the same as those of the priesthood in all primitive society. They performed rites and ceremonies connected with the worship of ancestral gods, located diseases and bodily ills by magical methods and practised an elaborate system of divination, which is described with more or less detail in the several early accounts. Disguised as a god or hidden behind or near a statue of the same, these priests gave oracular responses to those consulting them, making use of elaborate mechanism to deceive those who consulted the idols as oracles.

One of the most remarkable of these prophecies mentioned by Gomara in the middle of the sixteenth century has become historic. The father of the cacique, Guarionix, who ruled one of the five great Caciquedoms of Hayti, consulted the zemi regarding the fate of his gods and people, having prepared himself by fasting and purifications as the customs of his country required. He received this reply: Before many years there would come to the island bearded men with bodies clothed in mail, who with one stroke of the sword would sever men in twain, would bring fire over the land and drive from the earth the ancestral gods, destroying time-honored rites, and make blood flow like water. Gomera comments on this prophecy in his quaint way, adding that all these evils have followed in the wake of the advent of the Spaniards.

In a famous letter in which he describes his first voyage to America Columbus stated that the natives of Hispañiola or Hayti were without any religion, but on a later sojourn in their midst he was able to form more accurate ideas of their manners and customs and correct his earlier impressions. He found that, instead of being destitute of this universal human attribute, they recognized and worshipped many supernatural beings, which they represented by idols to which they gave the name zemis. Columbus discovered that they had special houses called temples set aside for this purpose in which these rude idols were set up, and that this cult was practiced by fraternities of priests who

exercised the healing art and consulted idols for oracular purposes. The idea of a future life was found to be universal among the inhabitants of the island. In a work ascribed to the Admiral's son, Fernando, the author sets forth more in detail the general character of this religion which his father found in the Antilles, and contemporary writers have supplemented it with an account of the exoteric character of the cultus of the natives of Cuba, Hayti and Porto Rico.

It is but natural that some of these writers, and those of the two centuries following that in which America was discovered, should have formed erroneous impressions of the nature of this cultus. Recognizing a well-developed idolatry, they sought and found in it, to their satisfaction, a god of good and one of evil, or two supreme deities, analogues of the Christian God and Devil. There could be no more erroneous and misleading explanation of the meaning of zemeism than this, and the error is apparent when we review subsequent historical interpretations in the light of modern ethnology. The misinterpretation threw discredit on all that had been written, most of which was strictly accurate so far as statement of facts was concerned, for while the Antilleans may not have had the ethical gods imputed to them by early writers, we need not deny them the possession of a religious sentiment, or agree with the conclusions of a prominent Porto Rican ethnologist that everything points to the belief that the Boriquen Indians were wholly destitute of religious ideas. There are to my mind many and conclusive archeological proofs which practically support what Columbus, Oviedo, Herrera and others state regarding the religion of the Antillean, although I am unable to accept the interpretation of its nature advanced by them.

In order to determine the nature of the Porto Rican aboriginal cultus, let us examine the writings of those who saw or knew of it first hand and have recorded their observations, and the available archeological material, a great amount of which has come down to our time in the shape of idols and religious paraphernalia.

It will be evident to any one who reads the early accounts of these images that the same names are applied indiscriminately to the idol and the spirit or magic power it represents, indicating that one personates or symbolizes the other.

Fray Roman Pane says that the Haytian caciques had certain stones called zemis which they religiously preserve; that each of these has a peculiar virtue; thus one can make grain sprout, another aids women to be delivered without pain, and the third is efficacious in bringing rain.

I shall later be able to give you some idea of the shape of some of these zemis from available archeological material, but it is sufficient at this point to note that magic powers were ascribed to certain stones. Stone zemis are the most numerous in all collections from the Antilles. But this was not the only material out of which these zemis were formed, for according to Oviedo and other writers various accounts have come down to us recording the forms of these images. They are said to represent various bizarre animals, frogs, turtles, snakes, lizards and birds. They had many specific names, and according to Fernando Columbus each clan chief had his own tutellary zemi with a characteristic name, and Gomarra in 1553 adds that they were named water, corn, safety and victory. Several Spanish writers state that both sun and moon were regarded as zemis by the people of Hayti, and according to Charlevoix these luminaries were supposed to have originated from a cave near Cape François

in the northern part of the island, where there were two large idols representing the sun and moon, and a pictograph evidently of the sun, and niches for the reception of minor idols.

It is an instructive and suggestive fact that the human race was believed to have emerged from the same cave, and on their advent upon the earth's surface men had the forms of various animals. The strange parallelism between this belief of the Antillean and that of the aborigines of the continent of America can be readily explained by a common theory, for in both cases these animals were clan totems.

The next aspect of the cult of the zemis, as derived from historical sources, is also significant in attempts at interpretation. Several of the older authors speak of the custom among the Antilleans of painting their bodies and faces, affirming that the cacique painted a figure of his zemi on his body, following in other words an almost universal custom among primitive man of decorating himself with his totem. There is good evidence that the totem as used by North American tribes was primarily a man's name and mark, and that etymologically the word refers to the pigment or earth used in painting a distinctive mark on the body. A strict abhorrence of incest and the necessity of bodily marks to distinguish members of the same clan naturally led to designs on the body which took the form of animals and plants or other natural objects. From their simple method of designating member clans by bodily markings so that a man could recognize his relatives has sprung a system of theoretical totemism which has been exaggerated by many well-known writers. Primarily the zemi which the Antillean painted on his body corresponds with the totem of the North American and zemeism is practically another name for totemism, a form of ancestor worship.

Certain statements of some of the older writers can be quoted to show that the Antilleans derived the clan from the zemi by descent. Herrera speaks of zemis named from ancestors, a statement Tejada in his valuable history of San Domingo repeats with addition. These supernatural beings personated by images of stone, clay and wood, or represented in paint on the bodies of the cacique, are said to be ancestral, or representations of the clan ancients pointing to the belief that zemeism was a form of ancients or ancestor worship, the individual zemis being tutelary clan ancients.

Other indirect evidence of ancestor worship can be found in the description given by early writers of certain objects found in the West Indies.

The sight of human skulls and bones in Carib houses, taken in connection with the stories of cannibalism with which the minds of the early discoverers were filled, naturally led to the belief that the Caribs were anthropophagous and the name Carib subsequently passed into literature as a synonym of cannibal.

It appears that the skulls of the defunct were preserved and kept in the houses, and it is probable that the sight of these heads led to the distorted accounts of cannibalism among the Caribs, which were found in the writings of the sixteenth century and copied with gruesome embellishments by later authors. The preservation of the skulls or other parts of the body of their ancestors is simply an aspect of ancestor worship which runs through the zemi cultus and is all-important in the religious ideas of all the Antillean aborigines. Although these preserved skulls were once so numerous, so far as I know only one specimen of human skull and body preserved as an object of worship has found

its way into the hands of the collector. This object taken from a cave near Maniel, west of the city of Santo Domingo, was figured in my article on zemis from Santo Domingo, and again in Dr. Cronan's history of the discovery of America. The body, made of woven fabrics with arms akimbo, is in a sitting posture, while the head is covered with cotton fabric, with artificial eyes inserted in the sockets of the skull. This specimen, one of the most instructive of all objects illustrating the Antillean cultus, was undoubtedly reverenced and regarded as an object of worship.

It is instructive in view of the ancestor worship which this specimen indicates to refer to certain mortuary customs of the prehistoric Antilleans as recorded by Oviedo. After describing the custom of wife burial with the dead, he says that in the interment of certain caciques the natives envelop the body in cotton cloth, place it in a grave which they cover with boughs and sticks, depositing with the dead the objects he prized most highly. The corpse was placed in the grave in a sitting posture on a seat called a *duho*, and for many days after burial areitos or ceremonial dances were held in its honor, in which the virtues of the deceased and his many good deeds in peace or war were extolled. No reference is made to the subsequent fate of the skeleton, but it is more than likely that it was later removed from its grave, which may account for the failure of archeologists to find the ancient Antillean sepultures.

The archeological material available for the study of the Antillean cultus is more complete than the historical, for there are several large collections in which many of these objects made of stone and wood are found in different museums in Europe and America, and still remain on the islands of Porto Rico and Santo Domingo, where there are several private collections of great value. The Latimer collection in the Smithsonian and the Stahl collection in the American Museum of New York are the largest in the United States, while the Neuman and Nazario collections on the island of Porto Rico are of great size.

A typical form of Porto Rican stone idol has a conical elevation, to which Mason has given the suggestive name 'mammiform figures.' The general character of these stones and the various bizarre animal heads which they represent answer all the documentary descriptions of zemis, and the fact that a similar object figured by Charlevoix with the legend 'zemi' proves their identity. This identification has been questioned in some quarters because in the majority of specimens the lower surface is concave, suggesting that they were used as paint mortars, but in a collection which I have examined at Bayamon this surface is convex and ornamented with incised lines, making it impossible for them to be used as mortars or for grinding purposes.

We find these zemis differing very greatly in size, in the kind of rock of which they were made, and the artistic finish. It is probable that they were once decorated with gold eyes and ear ornaments, which additions have, however, long ago disappeared. They represent frogs, birds, reptiles and various other animals with bizarre shapes, or are carved to represent grotesque human faces with body and limbs, as a rule, very reduced in size.

The most problematical structure of the mammiform zemi is a conical projection which most of them bear on their backs. It has suggested to Mason a symbol of the characteristic mountains of Porto Rico and other West Indian islands, the whole stone figure representing the genius of Boriquen, or a myth analogous to the story of Typhœus.

It is interesting to note that El Yunque, the highest peak of the island, when seen from the little coast town, Loquillo, has an appearance that suggests a conical zemi, with a central conical elevation and a lateral elevation on each side.

Thus far no zemis made of wood have been described from Porto Rico, but several from Hayti and the other Antilles, have been found in special niches in the walls of caves seated on god chairs, as several authors have described. In a report on my late visit to the Antilles I shall describe and figure one of the most perfect of these wooden zemis which has yet been recorded.

From what has been already given regarding the character of the zemis, as deduced from historical and archeological sources, it is possible to state in résumé the following conclusion regarding the nature of the worship which they illustrate. Roughly speaking, Antillean worship was a form of cultus called zemeism or ancestor worship, the zemi representing the clan ancient or tutelary god of the clan. These clan gods in stone and wood represented the ancestors of the clan, and were supposed to have, by virtue of their forms, the magic power of the ancestor.

The figures painted on the bodies of the caciques represent the clan tutelary beings, each different and characteristic as the clan differed. There is little doubt that when a cacique was thus painted with the figure of his tutelary in his own conception, as well as in that of his clan, he became that supernatural to all intents and purposes, just as when a Pueblo Indian puts on a mask with certain symbols he is transformed into the being which the symbolism of that mask represents.

Not only did each cacique or clan preserve as an object of worship, an idol representing his tutelary clan parent or zemi, but also his bodily decorations in certain dances and at other times represented that ancestor. In this occult or esoteric way he became a living personator of the ancestors worshiped by the clan of which he was chief. The painting of the body among the Antilleans appears to have taken the place of elaborate masks so common in North America, a practical expedient which the hot climate dictated.

But the Antilleans were likewise familiar with the use of masks in personations of their gods, and while these objects are not directly described as worn in their many ceremonial dances, there can hardly be a doubt that Dr. Chanca had this usage in mind when he wrote certain passages of his famous letter. That the Antilleans had masks of ceremonial import, not only references to them in the early Spanish writers show, but also wooden and stone masks existing in different collections demonstrate. Some of these, as one in the Capitol at Hayti, are of a size to fit the face, others are too small and too heavy to be worn, so that the probability is that most of these masks had become highly conventionalized in their use. They were not worn, but still functioned for the same purpose as if they were. They represented symbolically the clan zemi, but face and bodily decoration made their use as face coverings redundant. There is every probability that they were carried in the hands or attached to rods or other objects by those personating the ancients.

In strict accord with this interpretation of the symbolic masks of stone and wood are the repeated statements in the early chronicles that they were offered as gifts to those whom the giver thought to be supernatural, an act symbolizing the fealty of the clan god or zemi to a higher god. This is paralleled with modifications elsewhere in primitive American religions. Montezuma, believing Cortez a god, possibly Quetzalcoatl, sent him a bird snake mask of

wondrous workmanship. So also the early accounts say that on several occasions the Indians of the Antilles, as symbols of friendship or fealty, sent masks to Columbus. One of these, given by the Cacique Guacanagaei to Columbus on his visit to Hayti, is said to have been made of wood with tongue, eyes and nose of massive gold. This object no doubt resembled those of stone in the Latimer collection of the Smithsonian. Columbus saw many of these masks in Cuba on his first voyage, and on his return to the ill-starred colony of Navidad, on his second voyage, was met by an embassy of the same cacique bearing two masks with gold ornaments as regalia. These masks no doubt in both cases were symbolic of the supernatural power of the tutelary god of the cacique. The act of sending them was one of homage and respect of himself, his clan and the being worshiped. It is also instructive to note, as an evidence of a widespread custom among American aborigines, that with one of these symbolic masks Columbus also received as a present a belt ornamented with shells, stones and bones recalling, as Dr. Cronan has pointed out, the wampum of North American Indians.

The worship of ancestors which comes out so plainly in all proper interpretations of zemeism, appears likewise in the care of the dead and the whole nature of mortuary customs of both insular Caribs and Oronoco Guaraunos. From the existence of many skulls in the houses of the former it has been supposed that these people were anthropophagous, but it is probable, as has been shown above, that many of these skulls, carefully wrapped in basket ware or woven cotton coverings, were the crania of their own ancestors, preserved with pious care and used in the rites and ceremonies of ancestor worship. These skulls, artificially covered with cotton fabrics and attached to bodies of the same material, were seated on stone god chairs or *duhos,* and deposited in caves, but they were also kept in houses as the early records state.

We find in the descriptions of the Antilleans accounts of exercises called areitos which I have interpreted as ceremonial dances in which ancestors were personated. The short descriptions which have come down to us indicate, as a rule, that these dances had a religious motive in which the praise of the ancestors was only one, although a most important part. Great stress is laid by most writers on the fact that in these dances songs commemorating deeds of valor or personal worth of the dead were sung, and all agree that they occurred on all ceremonial occasions. The areito was undoubtedly a ceremonial drama, composed of rites public and secret, and accompanied semi-religious games, dances and various other elements. In these areitos the priests personated their ancestors, as do the Pueblos in their Katcinas, but with far different paraphernalia.

Although there is material available in documentary history for that purpose it would take me too long to describe the ceremonies of the prehistoric Antilleans, one of typical character which may be identified, a ceremony to the goddess of growth, which was one of the best known ceremonies of the prehistoric Antilleans, having been described by Gomara, Herrera, Haklyt, Tejada, Charlevoix and others. The latter gives a picture, somewhat fanciful, of the dance accompanying this ceremony, which is copied by Picard on his great work on the rites and ceremonies of all people.

The occurrence of this ceremony was announced publicly by a town crier directed by the cacique and consisted of a procession to the temple or house in which the image of the Earth Mother was

placed. The cacique led the line of dancers, and, when he had approached the entrance to the temple, seated himself near the idol, vigorously beating a drum to the sound of which the participants danced. The procession was composed of men, girls and women. The men had their bodies painted black, red, green and other colors and wore many ornaments of shell, and feathers in their heads. The girls and women bore baskets of cakes ornamented with flowers.

As the members of the procession approached the idol of the growth goddess they raised the flowers and baskets of cakes to the god as offerings with prayers, and later these offerings were divided into fragments and distributed among the people. The public dance was preceded by secret rites, but we have only fragmentary references regarding the nature of these rites. Benzoni records that the idol was decorated before the arrival of the procession and there are several references to the sprinkling of the same with prayer meal as occurs in all Hopi ceremonial rites, and mention is likewise made of ceremonial purification as a preparation for the rites.

We have very fragmentary historical accounts of the shape of the idol of the Earth Mother, and the figures given by Charlevoix and Picard represent a head composed of five different animals with that of the deer in the center. As old Peter Martyr says that the Haytians have several names for an idol in the form of a woman, one of which is earth and the other mother, I have ventured to translate her name Earth Mother, and identify the ceremony as one for growth of crops.

Time does not permit me to describe in detail this ceremony or to outline the reasoning which has led me to interpret it as a festival of the goddess of growth, but there is no doubt that the rites and the dance before the image of the goddess of the earth have for their object the growth of vegetation and increase of the crops upon which the Haytian relied for food.

Judging from the general life of primitive man we are forced to the conclusion that probably the majority of all the Antillean dances mentioned by the early Spanish writers were of a religious nature. As is most universal in primitive ritual rhythm played in them a most important rôle, and they were accompanied by a rude drum made of a log of wood or by a rasping of a stick over an elongated gourd incised with parallel lines. This latter instrument may be of African parentage, but it is still represented in Porto Rican folk music and sold to visitors as characteristic of the island.

The poetic beauty of the songs recounting the deeds of their ancestors in their areitos did not escape the attention of some of the chroniclers. We are tempted to recognize in the Boriquen, a national anthem of the Porto Ricans, some strains of melody which may have survived from aboriginal times, and the weird music which one hears from the palm-covered house of the mountaineer may yet be found to contain Carib survivals. We know that by royal edict of Ferdinand in 1513 the right of holding their areitos or ceremonial dances was allowed to the enslaved Indians, and perhaps there may yet survive in the cabins of the lowly at least some of the melody of prehistoric Porto Rico.

Whether there were special plazas set apart for these dances is a question of some interest, and in this connection may be mentioned certain level places surrounded by lines of stones set on edge found in several localities in the island. These enclosures are ordinarily supposed to have been constructed for the game of ball, called *bato*, and are circular or rectangular in shape. Some of these structures can still be seen in the mountainous districts near Utuado, and the sources of the Bayamon

River, but the majority have been destroyed, the flat bounding stones having been used for pavements or other purposes. It is conjectured that the rows of stones which form the periphery of these enclosures are the remains of seats for spectators, the judges or cacique occupying seats in the middle, as Oviedo describes. While ball games may have taken place in them, it seems to me highly probable from their mode of construction, situation, and other characters that they were also used as dance courts, in which were celebrated some of the solemn religious ceremonies of the clans.

From this imperfect sketch, and much more of a like import—which will be developed later in a more extended account of Antillean archeology—certain general conclusions have been drawn which have a relation to the early migrations of man on the American continent. The peopling of the Antilles is believed to have occurred at a comparatively modern date and to have been brought about by off-shoots of the Arawak stock migrating in old times from South America to Boriquen *viâ* the chain of islands forming the Lesser Antilles.

The peculiar culture of this race attained its highest development in Hayti and Porto Rico, where conditions were most favorable to its growth. Cuba and the Bahamas had likewise been peopled by the same race, but in neither of these islands was the culture the same as in the islands mentioned. The Lesser Antilles, exposed to inroads from savage South American tribes of the same stock as those of Porto Rico, were unable, from physical and agricultural conditions, to preserve the sedentary culture of the more central islands. They were practically the starting points of the foraging parties which constantly attacked Boriquen.

The cradle of the prehistoric Antillean culture was on the banks of the Orinoco and its tributaries in the great republic of Venezuela. His ancestors belonged to the Arawak stock of South America. His culture having naturally developed certain distinctive features in fluviatile waters, among great forests, became maritime, and spread from island to island until it came to Boriquen. There a part of the race became sedentary, but with the adoption of this kind of life lost much of its early prowess and daring, retaining only certain linguistic and other kinship with South American relatives.

In the same way the Caribs, another race related in some respects but distinct in others, swarmed out of the same Orinoco valley, coasted from island to island in the wake of its predecessor, and extended its excursions to Florida and our Southern States. This race also yielded to the insular environment, and, commingling its blood with that of the former, developed the composite culture we have called Antillean. These two peoples, and others of like kin, at first tribally distinct, though members of the same great stock by admixture and changed by environment, were fast coming to be homogeneous and thoroughly amalgamated when the advent of the European practically exterminated the Boriqueños and reduced the insular Carib to a wretched remnant of one of the finest native races of America.

Imperfect as is the data now available or possible to determine the nature of the prehistoric Porto Rico I will remind you that the problem of primitive culture is that of all the Antilles, and that we are on the threshold of a great subject, for, judging from collections of antiquities from the neighboring islands, I have no hesitation in saying that a vast amount

of new material awaits the advent of the archeologist and ethnologist in these islands.

It is reported that the terrible volcanic eruptions on the island of St. Vincent have blotted out the last remnant of the Caribs, but while local settlements may have been destroyed, the race is not yet extinct on the Lesser Antilles, and is well represented at various points in South and Central America, survivors offering many and instructive results awaiting our investigation. There remain also the kindred people in Guiana and Brazil, to a knowledge of whose life and customs Im Thurm, Ehrenrech and von den Steinen have added so much, and the relatives of the Caribs and Arawak scattered among the numberless tribes of the Oronoco valley, the *terra incognita* of American ethnology.

It is from a view of this kind over a special field that we get some idea of what there is for the anthropologist to do in the future, and the new problems awaiting solution. I have called your attention to only one of many in the science of man. There are more of equal or greater importance awaiting solution, which of late years especially claim the attention and study of American anthropologists. The unknown anthropological material opened to us by territorial growth is vast, and it is natural that when our anthropologists survey this great unknown awaiting research they should be serenely conscious of the future of our science. We have indeed every reason to be proud of the past achievements of American anthropology, in which this section has played a most creditable part, but the work before us is destined to yield still greater results, shedding a still brighter luster on American science.

J. WALTER FEWKES.

*REMARKS OF THE RETIRING PRESIDENT AND OF THE PRESIDENT-ELECT.**

IN introducing the president of the Association, Dr. Minot, the retiring president said:

My duty is very brief. I come here as the retiring officer of the Association to have, as the last act of my administration, the pleasant duty of handing over the responsibilities to one whom we all hold in the highest respect; one who stands for a very lofty ideal of scientific research; one who has attained, what many scientific men fail to attain, a reputation which extends far beyond the realms of science, practically speaking, for to him was accorded the privilege of discovering one of those features of the heavens which appeal to the imagination, the satellites of Mars. To the popular mind perhaps this great discovery stands as the most prominent service of my successor. I speak, not for myself, but as the mouthpiece of competent astronomers who have told me that this discovery, great as it is, represents only a small part, and not perhaps the greatest part, of the services which Professor Hall has rendered to astronomical science. This Association is indebted to him personally for many years of faithful service, of great helpfulness, and I esteem it the greatest possible honor that after having been myself president of this Association, I should have the pleasure of turning over the duties of the office to Professor Hall.

In replying to the speeches of Dr. Holland and other representatives of the local committee, President Hall said:

The American Association for the Advancement of Science comes to hold its summer meeting in your city. It is fortunate for us to meet in the city of Pittsburgh, famous for its wonderful production of iron and steel, materials which lie

* Reports received too late for insertion in the last issue of SCIENCE.

at the foundation of modern civilization. We are glad to see the homes of men who are the munificent benefactors of our libraries and of our scientific institutions. We shall be interested in visiting the great shops where you convert the products of a generous nature into articles for our daily use.

Our Association was founded for the encouragement and diffusion of scientific learning. Its creed is very simple. It requires in the novice only will and devotion. It is our business to study the works of nature by observation and experiment, and it is our duty to conform our conduct to her laws. We invite all to join us in this work, for we believe that along this line of investigation lies the true road of progress for the human family. But we are free. We do not wish to impose our ideas on others, but prefer to leave them to the operations of reason and judgment. If a brother goes astray, and tries to square the circle, there is no trial for heresy. We let him alone, feeling sure that time, the implacable enemy of error, will lead him back to the truth. Cicero tells us that time overthrows the opinions of men, and confirms the decisions of nature. With full confidence in this sentiment we go on in our work, 'without haste, and without rest.'

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*REPORT OF THE PERMANENT SECRETARY.**

THE fifty-second annual meeting of the American Association for the Advancement of Science, now drawing to its close, will be known as the first Pittsburgh meeting. In many respects it has been one of the most successful meetings which the Association has ever held. The attendance, while not very large, has been composed of members of the active working class, many of them being fellows, and the meeting may be safely characterized as a working meeting. The registration has shown four hundred and thirty-five members in attendance. This ranks the Pittsburgh meeting as the twelfth in size of the fifty-two meetings which have been held. It is the fourth in size of the meetings held during the past ten years. The geographic distribution of members in attendance is especially interesting, and those who have had the interest or curiosity to follow this matter of geographic distribution during recent years will notice that this year there is a larger attendance from the South than in any previous year. The exact representation by States has been as follows: Pennsylvania naturally heads the list with 178; New York, 59; Ohio, 49; District of Columbia, 45; Massachusetts, 23; Illinois, 21; Michigan, 10; Indiana, 10; New Jersey and Maryland, 8 each; Missouri, Minnesota, Kansas, New Hampshire, North Carolina, and West Virginia, 6 each; Texas and Nebraska, 5 each; Arkansas and Connecticut, 4 each; Alabama, Delaware, Virginia, California, Kentucky, and Canada, 3 each; Montana, 2; South Carolina, Georgia, Louisiana, South Dakota, North Dakota, Mississippi, Iowa, Colorado, and Maine, 1 each.

It must be remembered as usual that the number registered, namely, 435, includes only the active members and associates of the Association, and that as a matter of fact there are always a few members in attendance who are so characteristically forgetful of all things except scientific matters that they entirely fail to register. The number registered is only an indication of the size of the meeting. For example, eleven affiliated societies of a national scope have met with us and have swelled the gathering of scientific men in Pittsburgh during the past week to approximately 750 individuals. The meeting has,

* Presented at the closing session.

therefore, been a scientific congress of great importance.

The papers which have been read before the Association proper and in joint session with the more closely affiliated societies have been numerous and of a high order. About three hundred and sixty papers have been thus presented, which is a great increase over the number read at the last meeting of the Association.

A number of important measures concerning the future of the Association have been considered and amendments to the constitution have been adopted rendering the council more permanent in its membership and thus probably more efficient in its work, and also making the sectional committees so constituted as to render their greater efficiency a matter of practical certainty.

About sixty new members have been elected during the meeting, and about eighty members have been made fellows.

Pittsburgh and its vicinity have provided visiting points of great scientific interest, and the fact just stated, together with the great courtesy and hospitality of the local committee and the citizens of Pittsburgh, have combined to make the meeting now coming to a close a memorable one in the annals of the Association.

SCIENTIFIC BOOKS.

Reports of the Princeton University Expeditions to Patagonia, 1896–1899. IV., *Paleontology;* Part II., Tertiary Invertebrates. By A. E. ORTMANN, Ph.D. Princeton, the University. 1902. 4to. Pp. 45–332; pl. XI.–XXXIX.

The reports of the important expeditions sent to Patagonia by Princeton University are being published at the expense of the J. Pierpont Morgan fund, and in the present stately volume we have the details of the stratigraphic paleontology for which those interested in the geology of South America have been eagerly waiting.

The volume is printed with elegance and taste and the plates, while a little formal in drawing, are a refreshing contrast to the wretched phototypes which disfigure so many recent European paleontological memoirs. While the photographic process is suited to the reproduction, from the specimens, of a limited class of objects, in a limited number of cases, it completely fails to give what is required in the case of fossil mollusks. When small, all important details are apt to be lost; and, when large, the presence, in spots, of bits of detail, only emphasizes the general failure of the process as a whole. For this reason we congratulate the author and editor of this volume that they resisted the possible temptation and have given us illustrations which really illustrate. But one criticism occurs to us in reviewing the make-up of the volume, and that is a regret that an index to the paper is not included in it.

The memoir begins with an enumeration and description of the material collected. A painstaking comparison is made with analogous species in the northern hemisphere and also with the species of the Tertiary of New Zealand and Australia. From the Magellanian beds 19 species are described, from the Patagonian 151, and from deposits at and analogous to those of Cape Fairweather, 15 species are made known.

It has been known for some years that the opinions of several South American workers as to the age and stratigraphy of the Patagonian and other horizons, which they knew only from fossils collected by others, were much in need of revision. Two years ago Mr. J. B. Hatcher, in charge of the expedition, after careful inspection of the type localities, and Dr. Ortmann on the testimony of the fossils collected, arrived at certain conclusions which were published with sections in the *American Journal of Science* for 1900. The paleontological evidence upon which those conclusions rest is now furnished in the fullest detail. If any one hitherto has suspended judgment, he may now yield to conviction in full confidence that the case is proved. No question can arise,

after the present demonstration, as to the analogy which exists between the Chesapeake Miocene of North America and the Patagonian beds of Ortmann and Hatcher. The number of species which are known from the Magellanian beds is small, and they are not especially characteristic, but, taking the singular unanimity with which Oligocene strata in the New World and on the Pacific coast of Asia are associated with lignitic deposits, and the fact that such deposits overlie the Magellanian beds, it can hardly be doubted that we have here a series either Oligocene or upper Eocene. On the other hand as little doubt remains that the Cape Fairweather beds represent in the south the Pliocene of the northern hemisphere.

After discussing these questions historically and otherwise in the fullest manner, Dr. Ortmann concludes his memoir with a discussion of the theory of Antarctica, or the existence in geological time of land connections between the different austral countries. This portion of the paper is illustrated by an excellent bathymetric chart of the earth south of the thirtieth parallel of south latitude. The author accepts, in the main, the theory broached by Rütimeyer in 1867, as modified by Charles Hedley of Sidney, Australia, in 1895, that during the Mesozoic or older Tertiary time, a strip of land enjoying a mild climate extended across the south polar regions from Tasmania to Tierra del Fuego, approaching Tertiary New Zealand near enough, without joining it, to receive by flight or drift many plants and animals.

An excellent bibliography closes the text of this very creditable volume, on the publication of which we may congratulate the author and editor.

Das Eisen als das thätige Prinzip der Enzyme und der lebendigen Substanz. By N. Sacharoff. Translated into German by M. Rechtsamer. Jena, G. Fischer. Pp. 83. Two plates.

This monograph represents the attempt of the author to afford a comprehensive and universal explanation of the manifold phenomena which are ordinarily termed 'vital' reactions. An exposition of the importance of the deductive method in attacking the fundamental problems of biology forms the introduction to the discussion. In distinction from the cellular theory, a chemical theory of life is proposed. The cell is merely the mechanism which protects the living substance against the destructive forces of its environment, and secures the possibility of growth and reproduction; it is not an absolutely indispensable condition for the continuance of vital processes. The fundamental hypothesis of the author assumes as the cause of such processes a cleavage of the living substance brought about by the oxidation of minimal quantities of iron contained within it in the form of a nuclein—bionuclein. This cleavage is accompanied by hydrolysis. Complete anaerobiosis thus cannot exist.

The experimental evidence for the probability of this hypothesis is derived from a study of the behavior of gelatin towards the vegetable enzyme papayotin (papaïn). The action of enzymes depends upon the oxidation and reduction of the small quantities of iron-containing binuclein of which they are in part composed. Many of the facts ascertained by Spitzer in his extensive investigations on the oxidizing properties of the tissues are recalled. From data of this kind the explanation of a series of general biological phenomena is derived. For example, the formation of new molecules of living substance is attributed to a reconstruction and restitution of the remains of old molecules. The nucleus of the cell represents an available supply of the indispensable binuclein. The cell proper is an aggregate of similar molecules of living substance which occur in uninterrupted rows and are surrounded by a reducing substance. A detailed discussion of the various forms in which the hypothesis is applied to the most diverse phenomena, such as karyokinesis, muscular contraction, nervous irritability and conductivity, the action of the special senses and the central nervous system, cannot be entered into here. The monograph is a striking illustration of the translation of a very limited number of experimental observations into terms of universal application. We believe that the

reader will find as much of the obscure and undemonstrated in this attempt as has characterized other similar trials in recent years.

LAFAYETTE B. MENDEL.

SHEFFIELD SCIENTIFIC SCHOOL
OF YALE UNIVERSITY.

Linear Groups with an Exposition of the Galois Field Theory. By L. E. DICKSON, Assistant Professor of Mathematics in the University of Chicago. Leipzig, Teubner's Sammlung von Lehrbuchern auf dem Gebiete der mathematischen Wissenschaften. 1901. Vol. VI. Pp. x+312.

In 1898 the well-known firm of B. G. Teubner, Leipzig, Germany, began the publication of the 'Encyklopädie der mathematischen Wissenschaften mit Einschluss ihrer Anwendungen,' which is intended to give in seven large volumes a general outline of the known parts of mathematics, together with applications. As a comparatively small amount of space could be devoted to each subject, the same firm decided to publish a large series of advanced text-books in connection with this encyclopedia. This series was planned especially to enable the authors of articles for the encyclopedia to develop their subjects more fully, and thus make their articles more useful. Other writers are, however, invited to make the series as complete as possible.

More than fifty different volumes of this series have already been announced by almost as many different authors. The list of authors includes a number of prominent writers of various countries. The great majority of these are Germans, as might have been inferred from the fact that the work is due to German influence and is published by a German firm. Outside of Germany the Italians seem to have been the most active collaborators, but most of the other European countries, together with America, have promised contributions.

This series of text-books, together with the encyclopedia, will doubtless act as a very strong stimulus for greater mathematical activity, and it will tend to increase in a marked degree the German influence in higher mathematics. Never before has there been such extensive collaboration to make the recent progress in the various fields of mathematical research accessible to the student. It is hoped that this series will do much towards enabling many additional teachers of mathematics, who have sufficient leisure, to join the ranks of the investigators and to assist in developing the rich mines which have been opened in many quarters during the past few decades.

The present work is the sixth volume of the series and is devoted to a subject which has been developed principally on French and American soil. The fundamental ideas are due to the marvelous genius of Galois, who developed them in a memoir entitled 'Sur la théorie des nombres,' published in the *Bulletin des Sciences* de M. Férussac in 1830, when their author was only eighteen years old. This memoir contains the elements of a new kind of imaginaries which have since been known as the Galois imaginaries. They occupy practically the same position in the theory of congruences as the ordinary complex numbers occupy in the theory of equations.

The Galois imaginaries are generally studied by means of congruences with respect to a double modulus, composed of a prime number p and an irreducible function of a single variable $\phi(x)$. It has been known for a long time that the p^n different residue with respect to such a modulus constitute a *domain of rationality, Körper,* or *field.* That is, if these residues are combined with respect to addition, subtraction, multiplication or division (with the exception of division by zero) the result, when reduced with respect to the double modulus, is one of these p^n residues.

About ten years ago Professor Moore proved that every finite field may be represented as a field of this kind and he applied to it the present name *Galois field.* This important theorem exhibits the great generality of investigations with respect to the Galois field. In fact, with ordinary operational laws of algebra the generality is complete. Imbued with the beauty and interest which are attached to such general investigations, the author of the present volume has generalized all the systems of linear groups studied by Jordan with respect to the field of integers taken modulo p. He

has also studied new systems of linear groups in which the Galois field has been employed *ab initio*.

The aim of the present volume seems to be to give a systematic presentation of these results, together with the necessary theorems from the known parts of mathematics. Comparatively little knowledge is presupposed on the part of the reader, but the generality of the methods calls for considerable maturity and training. It is to an unusual extent the work of the author, and is a credit not only to him, but also to all the mathematicians of our country. We predict for it a place among the few American works on mathematics which are known and respected by the leading mathematicians of the world.

G. A. Miller.

Stanford University, Cal.

SCIENTIFIC JOURNALS AND ARTICLES.

The Botanical Gazette for June contains the following papers: Mr. A. Rimbach has recorded a series of physiological observations on the subterranean organs of ten Californian species of Liliaceæ. Although they are geophilous herbs of similar organization, they show very different modes of self-burial. The plants studied are grouped on the basis of these methods. Mr. Ralph E. Smith has studied 'The Parasitism of *Botrytis cinerea*,' and has come to the conclusion that too much importance has been ascribed to a cellulose-dissolving enzyme. The two stages in the process are a poisoning and a killing of the cells, and their disintegration and utilization as food by the fungus. The first effect seems to be produced by a substance, probably oxalic acid, formed by the fungus as a by-product of its metabolism. Following this a number of different enzymes are secreted that digest the various constituents of the tissues. Mr. Charles H. Shaw has published a study of 'The Development of Vegetation in the Morainal Depression in the Vicinity of Wood's Hole.' In open pools anchored plants with floating leaves are often confined to a zone somewhat separated from the shore, their approach to the shore line being prevented by the sweeping in of silt. The vegetation of the large open morainal pools, though undrained, may be purely hydrophilous, but about the time of the formation of the floating mat the conditions appear to become xerophytic. The marginal ditch which surrounds pond islands and atolls is formed only in the woods, where a dense felt of humus vegetation protects the ground from erosion. Fallen leaves and other organic materials swept from the forest tend to smother the vegetation which might grow there. In this way there is produced a belt of open water surrounding an island, or ring of vegetation. Mr. G. E. Webb has published a 'Morphological Study of the Flower and Embryo of *Spiræa*.' Some of the conclusions are as follows: The order of floral development is sepals, inner stamens, carpels, outer stamens, petals; no archesporial cell or plate of archesporial cells is differentiated in the microsporangium; the tapetum is cut off from the outside of the archesporial mass; several archesporial cells are differentiated in the megasporangium. Mr. David G. Fairchild describes a precocious poplar branch observed in Patras, Greece, and suggests the possibility of using such precocity in the production of earlier developing varieties of shade or fruit trees. Mr. E. Mead Wilcox records observations on the numerical variation of the ray flowers of *Helianthus annuus*.

DISCUSSION AND CORRESPONDENCE.

A METHOD OF FIXING THE TYPE IN CERTAIN GENERA.

In view of certain recent discussions* as to the proper means of fixing the types of genera of early authors, when no type was specified, we believe the differences of opinion arising under existing codes of nomenclature will be materially lessened by the adoption of the following rule:

* See *Cambridge, Ann. & Mag. Nat Hist.*, 7th Ser., VIII., pp. 403–414, November, 1901; ibid., 7th Ser., IX., pp. 5–20, January, 1902; Jordan, Science, N. S., XIII., pp. 498–501, March 29, 1901; Allen, *Bull. Am. Mus. Nat. Hist.*, XIV., pp. 325–334, November 12, 1901; Howell, *Proc. Biol. Soc. Wash.*, XV., pp. 1–9, February 18, 1902; Allen, *Proc. Biol. Soc. Wash.*, XV., pp. 59–66, March 22, 1902; Cook, Science, N. S., XV., pp. 647–649.

A generic name which is the same as that of an explicitly included species (or a cited post-Linnæan synonym of such species) takes that species as its type regardless of subsequent elimination.

Illustrations.

Cuvier in 1800 ('Leçons d'Anat. Comp.,' I., tabl. 1) proposed the generic name *Mephitis* for the American skunks and mentioned two species, *mephitis* and *putorius*. Consequently the type of *Mephitis* would be *Mephitis mephitis* (Schreber).

Bechstein in 1803 ('Orn. Taschenb. Deutschl.,' p. 282) proposed the genus *Totanus*, to which he referred the following species of birds: *maculatus, calidris, fuscus, natans, limosa, glottis, ægocephalus, leucophæus, lapponicus, gregarius* and *stagnatilis*. He quotes *Scolopax totanus* Linnæus as a synonym of *Totanus maculatus;* it would therefore be regarded as the type.

Cuvier in 1817 ('Regne Animal,' II., p. 269) proposed the name *Smaris* for a genus of fishes and mentioned two species, *mæna* and *smaris*, of which the latter would become the type.

J. A. ALLEN,
OUTRAM BANGS,
BARTON WARREN EVERMANN,
THEO. GILL,
ARTHUR H. HOWELL,
DAVID STARR JORDAN,
C. HART MERRIAM,
GERRIT S. MILLER, JR.,
E. W. NELSON,
MARY RATHBUN,
OLDFIELD THOMAS.

SHORTER ARTICLES.

THE PREVENTION OF MOLDS ON CIGARS.

IN January of the past winter a prominent cigar manufacturer brought to the attention of the Office of Vegetable Pathological and Physiological Investigations, U. S. Department of Agriculture, the fact that the occurrence of molds on cigars forms one of the greatest problems with which the tobacco manufacturer has to deal, and the loss in profits and in reputation from this cause alone is one of the most serious known to the manufacturer.

The undersigned was detailed to this investigation, and laboratory experiments were promptly begun. The molds found on the cigars were identified by Mrs. Flora W. Patterson, mycologist, as *Aspergillus candidus* Link and *Penicillium glaucum* Link. Preliminary tests showed promptly that these molds would not grow under laboratory conditions on untreated wrapper leaf, but when a thin film of tragacanth paste, such as is used in cigar factories for fastening the wrapper in place, was applied to the leaf the molds flourished. Whether to disinfect the wrapper leaf or the paste was a question answered in favor of the latter method. The question of choosing some substance which should be lacking in odor, taste and harmful properties, was decided in favor of boracic acid. A large number of compounds was tested, but the number of those efficient under the conditions here prescribed was extremely limited. Boracic acid is well known as a perfectly harmless antiseptic agent, a fact which further recommended it. Laboratory tests showed that a saturated solution of boracic acid used in making up the tragacanth paste, instead of water, sterilized the paste. A method of operation adapted to factory purposes, based on this laboratory information, was transmitted to the factory from which the complaint first emanated. After a six-weeks' test, under the most varying conditions in factory practice, the superintendent writes: "I am happy to state that I sincerely believe that you have solved the trouble of the mold forming on the heads of cigars at our factory, as since I have been using the boracic acid in the proportion prescribed we have no trouble with the mold on the cigars. I thought that possibly after they had been stored some time the mold might appear, but I am pleased to say that our tests in every way and under all conditions show that the mold will not appear after using the boracic acid in the paste. I would add that as boracic acid is cheap, we now buy it by the barrel."

Since the cost involved in this treatment is practically nothing, and the additional labor involved in the application is also so slight as

to be practically *nil*, we may hope that perhaps this difficulty is eliminated.

Rodney H. True.

Bureau of Plant Industry,
Department of Agriculture.

GRADUATE SCHOOL OF AGRICULTURE.

The Graduate School of Agriculture, the first of its kind in the United States, began a four weeks' session at Ohio State University, Columbus, Ohio, July 7. About 70 students from 25 States are in attendance, of whom nearly 50 are officers of agricultural colleges and experiment stations. The faculty consists of about 30 leading teachers and investigators in agricultural science. Advanced courses are given in agronomy, breeding of plants and animals, zootechny and dairying. At the inaugural exercises held on the evening of July 7 addresses were delivered by Hon. James Wilson, Secretary of Agriculture; Hon. Wm. M. Liggett, dean of the College of Agriculture of the University of Minnesota; Dr. H. C. White, president of Georgia State College of Agriculture and Mechanic Arts; Dr. A. C. True, director of U. S. Office of Experiment Stations and dean of the Graduate School of Agriculture; and President W. O. Thompson, of Ohio State University. In his address explaining the objects and aims of this school the dean showed that the rapid development of agricultural education and research in this country in recent years had created a demand for well-trained teachers and investigators which the agricultural colleges as at present organized could not meet. Especially had the latest development in the direction of the division of the general subject of agriculture into specialties created a necessity for university instruction in agriculture. "One aim of this graduate school is to provide a certain measure of this advanced and special instruction and thereby to illustrate some of the lines along which our universities need to establish advanced courses of instruction in agricultural specialties." The school may also serve a useful purpose in bringing to its students up-to-date information on various agricultural subjects and in pointing out ways in which the methods of teaching and investigating agricultural subjects may be improved, and the apparatus and illustrative material for instruction and research in these subjects may be increased in variety and effectiveness. The school serves to solidify and amplify the organization of agricultural education and research on the basis of agriculture itself, considered as both a science and an art. "The signs all indicate," said Dr. True, "that we are on the edge of a widespread movement to organize agricultural education in this country on a much broader basis in order that it may permeate the mass of our rural population. The people are looking to the agricultural colleges to lead in this movement. In a large way it may be said that the hoped-for leaders in this new enterprise are here assembled. Surely our councils will have been futile if they do not give an impetus and direction to the plans for popular agricultural education now being formulated. The people are already offering our higher institutions for agricultural education and research relatively large sums of money and are evidently intending to give them more. If we can find a way here to make the work of our agricultural colleges, experiment stations and Department of Agriculture in any respects more effective and satisfactory, we shall surely reap ample reward in increased material support for our instruction and researches and stronger popular confidence in our usefulness as instruments of agricultural advancement."

Considering the character of the faculty and students of this school important results may be expected from the inauguration of this new enterprise in agricultural education.

SCIENTIFIC NOTES AND NEWS.

The Albert medal of the Society of Arts, London, has for the present year been awarded to Professor Alexander Graham Bell, for his invention of the telephone.

President Eliot, of Harvard University, was elected president of the National Educational Association at the recent Minneapolis meeting.

The eminent astronomer, Professor Giovanni Schiaparelli, has been elected an associ-

ate of the French Academy of Sciences in the room of the late Baron Nordenskiöld.

THE full list of coronation honors as far as they concern men of science is given in *Nature* as follows: Among the new Privy Councillors are Lord Kelvin and Lord Lister. The new Baronets include Sir Andrew Noble, K.C.B., Sir Francis Laking and Sir Frederick Treves. The honor of Knighthood has been conferred upon Dr. J. W. Collins, F.R.C.S., Mr. A. Cooper, F.R.C.S., Mr. H. Croom, president of the Royal College of Surgeons (Edinburgh); Dr. T. Fraser, F.R.S., president of the Royal College of Physicians of Edinburgh; Mr. Victor Horsley, F.R.S., Mr. H. G. Howse, president of the Royal College of Surgeons; Principal Oliver Lodge, F.R.S., Professor W. Macewen, F.R.S., Principal Rücker, F.R.S., and Mr. J. Thornycroft, F.R.S. In the Order of the Bath (Civil Division) Sir William Church, Bart., president of the Royal College of Physicians, and Professor W. Ramsay, F.R.S., have been appointed Knight Commanders, Major Ronald Ross, F.R.S., and Professor A. M. Worthington, F.R.S., have been appointed Companions of the same Order. In the Military Division of the Order of the Bath, Admiral Sir Erasmus Ommanney, F.R.S., has been appointed Knight Commander. The Kaiser-I-Hind medal for public service in India has been granted to Mr. Edgar Thurston, superintendent, Government Central Museum, Madras. Finally, the new Order of Merit includes in its list of twelve original members the names of four distinguished men of science, namely, Lord Rayleigh, Lord Kelvin, Lord Lister and Sir William Huggins.

THE International Committee upon Atomic Weights, composed of representatives from all the greater chemical organizations of the world, has been reorganized, by a vote of its own membership, into a working committee of three. These are F. W. Clarke, of Washington, chairman; T. E. Thorpe, of London, and Carl Seubert, of Hannover, Germany.

TRINITY COLLEGE has conferred the degree of LL.D. on Professor W. L. Robb, who leaves that institution to take charge of the Department of Physics and Electrical Engineering at the Rensselaer Polytechnic Institute.

MR. F. H. NEWELL, chief hydrographer of the U. S. Geological Survey, has gone to the West to supervise surveys in connection with the work in irrigation authorized by Congress. Surveying parties are in the field in California, Oregon, Washington, Montana, Utah, Nevada, Idaho, Arizona and Colorado.

ON July 1, by order of the Secretary of Agriculture, Dr. Ch. Wardell Stiles, who has been serving temporarily as pathologist of the U. S. Bureau of Animal Industry, resumed his regular duties as zoologist of the bureau, and Dr. John R. Mohler, formerly assistant pathologist, has been promoted to the position of pathologist.

PROFESSOR EDWARD S. HOLDEN, U.S.M.A., '70, has accepted the appointment of librarian of the Military Academy at West Point. The library now contains about 45,000 volumes. Congress has provided a much-increased appropriation—$11,500—for the present fiscal year and its collections are likely to grow rapidly. The interior of the large library building has lately been remodeled at a cost of $85,000.

THE Executive Commission of the International Congress of Applied Chemistry, which met at Paris in 1900 and is to meet at Berlin next year, has appointed an international committee on analytical methods. The American members of this committee are H. W. Wiley and F. W. Clarke.

AT the general meeting of the Zoological Society of London on June 19 the gold medal of the Society was delivered by His Grace, the Duke of Bedford, K.G., president, to Sir Harry Johnston, G.C.M.G., K.C.B., F.Z.S., in consideration of his great services to zoological science during the various official posts which he had held in Africa and especially in commemoration of his discovery of the Okapi. After the close of the meeting the third of the series of zoological lectures for the present year was delivered by Professor E. Ray Lankester, F.R.S., on 'The Okapi and its Position in the Natural Series.' Professor Lankester's Memoir in the society's quarto 'Transactions,'

which contains a full account of all that is known of 'the new African mammal' up to the present date, is expected to be ready very shortly.

Among those who will be carrying on biological work this summer at the U. S. Fish Commission Laboratory at Wood's Hole are Dr. Robert P. Bigelow, Massachusetts Institute of Technology; Professor W. K. Brooks, Johns Hopkins University; Professor Hubert L. Clark, Olivet College; Professor Wesley R. Coe, Yale University; Dr. Ulric Dahlgren, Princeton University; Professor Bashford Dean, Columbia University; Professor F. P. Gorham, Brown University; Professor C. W. Hargitt, Syracuse University; Professor C. Judson Herrick, Denison University; Dr. George T. Moore, U. S. Department of Agriculture; Professor George H. Parker, Harvard University; Miss Harriet Richardson, Columbian University; Professor W. M. Smallwood, Syracuse University; Dr. F. B. Sumner, College of the City of New York; Professor R. W. Tower, Brown University; Dr. Rodney True, U. S. Department of Agriculture, and Dr. Charles B. Wilson, Massachusetts State Normal School.

Dr. John Daniel Runkle, professor of mathematics at the Massachusetts Institute of Technology since its foundation and president from 1870 to 1878, died at Southwest Harbor on July 8. He was born in New York State in 1823 and graduated from the Lawrence Scientific School in 1851. He was then engaged on the staff of the 'Nautical Almanac' until the establishment of the Massachusetts Institute in the plans for which he took an active part. In addition to his important work for the institute Dr. Runkle did much to introduce manual training in the schools.

The death is announced of M. Hervé Faye, the eminent astronomer, at the age of eighty-eight years. He was the oldest member of the Paris Academy of Sciences, having been elected in 1847. M. Faye has been since 1873 professor of astronomy in the Ecole polytechnique.

The first volume of the International Catalogue of Scientific Literature is reported by the English papers to have been published. It contains part of the botanical literature for the year 1901.

Nature states that the annual general meeting of the Marine Biological Association of the United Kingdom was held in the rooms of the Royal Society on June 25. The officers and council elected for the year 1902–3 were as follows: President, Professor E. Ray Lankester, F.R.S.; hon. treasurer, Mr. J. A. Travers; hon. secretary, Dr. E. J. Allen; council, Mr. G. P. Bidder, Mr. G. C. Bourne, Mr. Francis Darwin, Professor J. B. Farmer, Dr. G. H. Fowler, Dr. S. F. Harmer, Professor W. A. Herdman, Professor G. B. Howes, Mr. J. J. Lister, Professor E. A. Minchin, Professor C. Stewart, Professor D'Arcy W. Thompson and Dr. R. N. Wolfenden. The following governors are also members of council: Mr. J. P. Thomasson (the prime warden of the Fishmongers' Company), Mr. E. L. Beckwith (Fishmongers' Company), Sir J. Burdon Sanderson, Bart. (University of Oxford), Mr. A. E. Shipley (University of Cambridge), Professor W. F. R. Weldon (British Association for the Advancement of Science).

The Electrical World states that the Imperial German Post Office has just appointed a commission to go to the United States and study American postal, telegraphic and telephone systems. Special attention will be given to the tubular mail service. Germany at present is using only small tubes for individual letters, and contemplates introducing the American system of transmission in bulk by mail to and from the branches of the central post office. The commissioners are Post Councillors Wernecke, of Leipzig, and Braun, of Hamburg. They will be accompanied by a telegraphic engineer and another engineer of Berlin.

The Committee appointed by the Institution of Electrical Engineers to hold an inquiry on electrical legislation, consisting of Professor J. Perry, F.R.S., president, and Professor W. E. Ayrton, F.R.S., Major P. Cardew, R.E., Lieutenant-Colonel R. E. Crompton, C.E., Mr. S. Z. de Ferranti, Mr. Robert Hammond, Mr. H. Hirst, Mr. J. E. Kingsbury, Mr. W. L.

Madgen, Mr. W. M. Mordey, Mr. R. P. Sellon, Mr. Siemens, Mr. C. P. Sparks, Mr. J. Swinburne, Mr. A. A. Campbell Swinton, and Professor Silvanus P. Thompson, F.R.S., has issued its report. According to an abstract in the London *Times*, the committee met on eleven occasions and heard the evidence of a number of representative experts. The witnesses were practically unanimous in their conviction that electrical enterprise had not attained its due position in England. A joint select committee of the two Houses of Parliament in 1898 reported that the law should be amended as regards the veto exercised by local authorities, but no steps have been taken to give effect to that recommendation. The opinions of the committee are embodied in resolutions to the effect that, notwithstanding that Englishmen have been among the first in inventive genius in electrical science, its development in the United Kingdom is in a backward condition, as compared with other countries; that the cause of such backwardness is especially due to the restrictive character of the legislation governing the initiation and development of electric power and traction undertakings, and the powers of obstruction granted to local authorities; that local boundaries have usually no reference whatever to the needs of the community in regard to electric supply and traction, and that the selection of suitable areas should be dealt with on the basis of economic principles and industrial demands; that the development of electric power and traction undertakings offers the most favorable means of relieving congested centers; that it is expedient in the national interests that the Electric Lighting Acts, 1882–8, the Tramways Act, 1870, and the Standing Orders relating to special Acts for tramways should be amended in so far as they enable local authorities to veto or delay the carrying out of electric supply and traction projects of which the utility can be shown, and that effect should be given to the recommendations of the joint select committee of Parliament, 1898, on 'Electrical Energy—Generating Stations and Supply'; that while this committee fully recognizes the ability of the technical officials of the government departments concerned, it is of opinion that the staffs of those departments, as at present existing, are wholly inadequate having regard to the great industrial interests involved, and that it is essential that these departments should be put into a position enabling them to keep in touch with all developments in engineering matters, both at home and abroad, and that a sufficient sum should be provided annually by government to enable them to employ and pay a proper staff for such purposes; that the adjustment of departmental regulations to engineering development should not be delayed until the industrial interests concerned are seriously hampered, and that, with a view to preventing any such delay, the Institution of Electrical Engineers should be willing to take part in revising such regulations from time to time; that this committee recommends that the institution should memorialize the prime minister to receive a deputation for the purpose of urging the removal of the present disabilities and restrictions which prevent electrical engineering from making the progress that the national interests demand, and attaining at least the same level as in America, Germany and other industrial countries.

THE United States Geological Survey has resumed field work for the topographic mapping of a portion of Michigan. The special map on which work is now being done will be known as that of the Ann Arbor quadrangle, representing the district surrounding the city of that name. Like other topographic maps issued by the Geological Survey, not only the ordinary features will appear in detail, but also the relief or topography of the country, with elevations above sea level. Topographic features of special interest which will be represented on the Ann Arbor map are the terminal moraine passing through Ann Arbor and the old shore lines of Lake Erie. The professors and students at the university are interested in the work, and it will afford the students an opportunity for field practice. The work is under the supervision of Topographer E. C. Bebb.

THE *British Medical Journal* states that at a meeting of representatives of the German medical press, held not long ago, the follow-

ing regulations for the conduct of scientific controversies were adopted: (1) Every controversy shall be brought to a close by a final reply from the writer who opened the debate; only in exceptional cases shall an opponent be allowed a second reply. (2) A reply may be inserted in small type, and at the end of the journal, even when the article animadverted on was published as an original communication. (3) The editor has the right to send a copy of the criticism to the author of the article attacked, even before its insertion.

UNIVERSITY AND EDUCATIONAL NEWS.

Mr. Frederick W. Vanderbilt has given to the Sheffield Scientific School of Yale University, of which he is a graduate, a valuable tract of land and will build upon it a dormitory. The value of the gift is not known, but it is reported to be $500,000.

Dr. D. K. Pearsons has added $50,000 to the $200,000 he has already given to Whitman College, Walla Walla, Washington.

The late Rev. Henry Latham, master of Trinity Hall, Cambridge, has left about $35,000 to the university to form a fund, from which grants may be made to members of the university who are incapacitated by age or infirmity, and to their widows and families.

The Public Health Institute, Edinburgh, completed by the liberality of Sir John Usher, has been handed over to the university.

The Wesleyan University summer school of chemistry and biology has just opened, with an attendance of thirty-six.

The universities of the Maritime Provinces of Canada are sending a memorial to the executors of Mr. Rhodes's will asking that the conditions of the will be altered so as to give all the provinces of the Dominion an opportunity to compete for the Oxford scholarships. The will provides only for Ontario and Quebec, two out of seven provinces.

The president of Waynesburg College, Waynesburg, Pa., sends us a note to the effect that at the recent commencement the institution conferred the degree of Ph.D. on President Z. X. Snyder, of the Colorado Normal School. According to 'Who's Who' President Snyder was given the degree of Ph.D. by Waynesburg College in 1876. It is to be hoped that Waynesburg College will limit the conferring of the degree of Doctor of Philosophy *causa honoris* to President Snyder.

Professor T. W. Galloway, of Missouri Valley College, has been elected to the chair of biology of the new James Millikin University, at Decatur, Ill., and is succeeded at Missouri Valley College by Dr. Lawrence E. Griffin, assistant in zoology in the Western Reserve University.

F. L. Stevens, Ph.D. (Chicago), has been advanced from an instructorship to a full professorship in the new department of biology at the College of Agriculture and Mechanic Arts at Raleigh, N. C.

Several laboratory assistantships in elementary chemistry are available at the University of Illinois, Urbana, Illinois, for the coming school year. The pay for these assistantships is $300 per year, and the work consists in laboratory instruction in general elementary chemistry; the arrangement being that the assistant shall give one half of his time to the work and devote the other half of his time to research work in some branch of chemistry as arranged with the head of the chemistry department.

In connection with the grant of £10,000 a year recently voted to the University of London by the London County Council in aid of the work of the Faculties of Arts, Science, Engineering, and Economics, the Senate have made the following appointments: Professor Ramsay, F.R.S., teacher of chemistry at University College; Professor Capper, teacher of mechanical engineering at King's College; Professor Unwin, F.R.S., teacher of civil and mechanical engineering at the Central Technical College, and Dr. J. Norman Collier, F.R.S., professor of organic chemistry at University College.

At St. John's College, Cambridge, Mr. G. B. Mathews, F.R.S., senior wrangler in 1883, has been reelected to a fellowship and Mr. J. H. Vincent, D.Sc., has been elected to a Hutchinson studentship in physics.